THE NATURAL HISTORY OF ANIMALS



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The Natural History of Animals



KINGFISHERS (ALCEDO ISPIDA)

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KINGFISHERS (*Alcedo ispida*)

The Common Kingfisher of Britain, which ranges through Europe and the greater part of Asia, is remarkable for its brilliant plumage. The plate depicts two of them perched on branches overhanging a stream, on the look-out for fish, which constitute their favourite prey. The structure of the feet greatly assists in the maintenance of this characteristic attitude, three of the toes being closely bound together and forwardly directed. On sighting its prey the Kingfisher darts down with arrow-like flight, and uses its long sharp beak as a fish-spear. Once secured the booty is taken from the water and beaten against the branch to stop its struggles, as a preliminary to swallowing. Kingfishers also hawk along the surface of the water, diving vertically with great rapidity as opportunity may offer. When the wings are closed the extended body is shaped like a rounded wedge, well suited for cleaving the water with but little friction.

The Natural History of Animals

The Animal Life of the World in its various Aspects and Relations

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HALF-VOL. III

LONDON
THE GRESHAM PUBLISHING COMPANY
34 SOUTHAMPTON STREET, STRAND

QL
45
A29
V.3

A375437

CONTENTS

HALF-VOL. III

THE FOOD OF ANIMALS

Page

INTRODUCTORY 1

CHAPTER I.—THE FOOD OF ANIMALS—FLESH-EATING MAMMALS (CARNIVORA)—WHALES (CETACEA)

FLESH-EATING MAMMALS (CARNIVORA)

A. TERRESTRIAL CARNIVORES (FISSIPEDIA)

1. CAT FAMILY (Felidæ)—Common Cat, Lion, Leopard, Tiger, Jaguar, Puma, Hunting Leopard, Fishing Cat - 5

2. CIVET-CAT FAMILY (Viverridæ)—Foussa, Civet-Cats proper, Mampalon, Mangoustis - 11

3. HYÆNA FAMILY (Hyænidæ)—Ordinary Hyænas, Earth-Wolf or Aard-Wolf 14

4. DOG FAMILY (Canidæ)—Dogs, Wolves, Jackals, and Foxes 15

5. LARGE BEAR FAMILY (Ursidæ)—Polar Bear 19

6. WEASEL FAMILY (Mustelidæ)—Glutton, Weasels, Polecats, Martens, Stoats, Otters - 20

B. AQUATIC CARNIVORES (PINNIPEDIA)

General Characters; 7. SEAL FAMILY (Phocidæ); 8. SEA-LION FAMILY (Otaridæ); 9. WALRUS FAMILY (Trichecidæ) - 24

PORPOISES, DOLPHINS, AND WHALES (CETACEA)

General Characters - 25

A. TOOTHED WHALES (ODONTOCETI)

1. DOLPHIN FAMILY (Delphinidæ)—Porpoise, Killer-Whale, Common Dolphin, Fresh-water Dolphins 26

2. SPERM-WHALE FAMILY (Physeteridæ)—Sperm-Whale or Cachalot 29

B. TOOTHLESS OR WHALEBONE WHALES (MYSTACOCETI)

Rorqual, Right or Greenland Whale 29

CHAPTER II.—THE FOOD OF ANIMALS—MAMMALS WHICH CHIEFLY FEED ON INSECTS AND OTHER SMALL CREATURES

Page

INSECT-EATERS PROPER (Insectivora)—General Characters; Hedgehog, Tenrecs, Golden Moles, Shrews, Desmans, African River-Shrew, Mole-Shrews, Common Mole, Star-nosed Mole, Tree-Shrews, Elephant-Shrews 31

BATS (Cheiroptera)—General Characters; Long-tongued Vampires, Long-tongued Shrew-Bat, True Vampires, Javelin Bats 38

CHAPTER III.—THE FOOD OF ANIMALS—LOWER MAMMALS WHICH CHIEFLY FEED ON INSECTS AND OTHER SMALL CREATURES

MAMMALS POOR IN TEETH (Edentata)—Great Ant-Eater, Cape Ant-Eater or Aard-Vark, Scaly Ant-Eaters or Pangolins 41

POUCHED MAMMALS (Marsupialia)—Banded Ant-Eater, Bandicoots, Marsupial Mole 42

EGG-LAYING MAMMALS (Monotremata)—Spiny Ant-Eaters 44

CHAPTER IV.—THE FOOD OF ANIMALS—CARNIVOROUS BIRDS

Ancient Toothed Birds; Birds of Prey—Falcons, Owls, Secretary Bird, Osprey or Fishing-Eagle; Fish-eating Birds—Cormorants, Darters or Snake-Birds, Gannet, Pelicans, Gulls and Terns, Skuas, Scissor-Bills or Skimmers, Frigate-Birds, Albatrosses, Storm Petrels, Divers, Penguins, Kingfishers, Herons, Storks 45

CHAPTER V.—THE FOOD OF ANIMALS—BIRDS WHICH CHIEFLY FEED ON INSECTS AND OTHER SMALL CREATURES—SCAVENGERS

Birds that feed on Insects, &c.—Swallows and Swifts, Night-Jar or Goat-Sucker, Woodpeckers, Cuckoo, Creepers, Blue-Roller, Fly-Catchers, Tyrant Fly-Catchers, Ox-Peckers, Honey-Guide, Huia, Shrikes or Butcher Birds, Ducks and Swans, Wagtails, Turnstone and Oyster-Catcher, Godwits and Curlews, Woodcock, Kiwi 56

Scavenging Birds—Vultures and Adjutants 69

CHAPTER VI.—THE FOOD OF ANIMALS—CARNIVOROUS AND INSECTIVOROUS REPTILES

CROCODILES (Crocodilia)—Nile Crocodile, Garials 70

TORTOISES AND TURTLES (Chelonia)—Snapper Tortoises, Hawk-bill Turtle, Snake-necked Tortoises 71

LIZARDS (Lacertilia)—Monitors, Geckoes, Chameleons, Skinks, Amphisbænas, Snake-like Lizards 73

SNAKES (Ophidia)—General Characters; Grass Snake, Pythons and Boas, Shield-tailed Snakes and Blind Snakes; Poisonous Snakes—Whip-Snakes, Coral-Snakes, Cobras, Asps, Death-Adders, Sea-Snakes, Adder, Puff-Adder, Rattle-snake 76

CHAPTER VII.—THE FOOD OF ANIMALS—AMPHIBIANS AND FISHES OF CARNIVOROUS AND INSECTIVOROUS HABIT

Page

AMPHIBIANS (Amphibia)—Grass Frog, Common Toad, Tree-Frogs, Spotted Salamander, Newts and Fish-Salamanders, Cæcilians 82

FISHES (Pisces)—Lung-Fishes or Mud-Fishes (Dipnoi). Ordinary Bony Fishes (Teleostei)—Perches, Mackerels, Pike, Angler-Fish or Fishing-Frog, Deep-sea Angler, Wrasses and Wolf-Fishes, Electric Cat-Fishes and Electric-Eel, Mud-Skippers, Beaked Chelmon. Sharks and Rays (Elasmobranchii)—Blue Shark and Rondeletian Shark, Thresher, Saw-Fishes, Port Jackson Shark, Eagle-Ray, Electric-Rays. Round-Mouths (Cyclostomata)—Lampreys and Hags 83

CHAPTER VIII.—THE FOOD OF ANIMALS—NEMERTINES AND CARNIVOROUS MOLLUSCS

NEMERTINE WORMS (Nemertea) 93

MOLLUSCS (Mollusca)—Cuttle-Fishes and Squids (Cephalopoda)—General Characters. Snails and Slugs (Gastropoda)—General Characters; Purple-Shell, Common Whelk, Cone-Shells, Natica, Heteropods, Tectibranchs, Sea-Slugs, Lung-Snails 94

CHAPTER IX.—THE FOOD OF ANIMALS—CARNIVOROUS INSECTS

General Characters. Membrane-winged Insects (Hymenoptera)—Driver-Ants, Foraging-Ants, Sand-Wasps, Ichneumon-Flies. Beetles (Coleoptera)—Tiger-Beetles, Ground-Beetles, Rove-Beetles, Water-Beetles, Lady-Birds, Scavenging Beetles. Net-winged Insects (Neuroptera)—Biting-Lice, Snake-Flies, Scorpion-Flies, Ant-Lions, Mantis Net-Wings, Lace-wing Flies, Golden-eyed Flies, Dragon-Flies, May-Flies and Stone-Flies, Caddis-Flies. Straight-winged Insects (Orthoptera)—Soothsayers or Praying Insects. Scale-winged Insects (Lepidoptera)—Fur-eating Caterpillars, Purple Emperor Moth. Two-winged Flies (Diptera)—Stable-Fly, Tsetse-Fly, Gad-Flies, Gnats and Midges, Forest-Flies, Fleas. Bugs (Hemiptera)—Land-Bugs, Water-Bugs, Marine Bugs, True Lice - 101

CHAPTER X.—THE FOOD OF ANIMALS—CARNIVOROUS ARACHNIDS AND MYRIAPODS—PERIPATUS

SPIDER-LIKE ANIMALS (Arachnida)—Scorpions (Scorpionidæ). Whip-Scorpions (Pedipalpi). Spiders (Araneidæ)—General Characters; Web-Spinners, Bird-catching Spiders, Wolf-Spiders, Water-Spiders, Jumping Spiders. False Spiders (Solpugidæ). False Scorpions (Pseudoscorpionidæ). Harvestmen (Phalangidæ). Mites and Ticks (Acarina) 125

MANY-LEGGED ANIMALS (Myriapoda): Centipedes (Chilopoda)—Thirty-Foot, Tropical Centipedes, Earth Centipedes, Shield-bearing Centipedes - 132

PRIMITIVE AIR-BREATHERS (Prototracheata)—Peripatus 134

CHAPTER XI.—THE FOOD OF ANIMALS—CARNIVOROUS CRUSTACEANS AND KING-CRABS

CRUSTACEANS (Crustacea): Higher Crustacea (Malacostraca)—Long-tailed Decapods—Lobster, Prawn, Shrimp, Crayfish, Jamaica Prawn, Rock-Lobster,

Page

Hermit- or Soldier-Crabs; Short-tailed Decapods—Common Crabs, Gulf-weed Crab, Swift Land-Crabs. Mantis-Shrimps (Stomatopoda). Sessile-eyed Crustacea (Edriopthalmata)—Sand-Hoppers, Skeleton-Shrimps, Slaters.—Lower Crustacea (Entomostraca), Parasitic Forms 135

KING-CRABS (Xiphosura) 144

CHAPTER XII.—THE FOOD OF ANIMALS—CARNIVOROUS ANNELIDS AND SIPHON-WORMS

ANNELIDS (ANNELIDA)

BRISTLE-WORMS (Chætopoda)—Sea-Centipede, Sea-Mouse 146

LEECHES (Discophora): Jawed Leeches—Medicinal Leech, Land-Leeches; Jawless Leeches—Horse-Leech 147

SIPHON-WORMS (GEPHYREA)

Common Siphon-Worm, Bristly Siphon-Worms, Green Bonellia 149

CHAPTER XIII.—THE FOOD OF ANIMALS—CARNIVOROUS UNSEGMENTED WORMS AND ECHINODERMS

PLANARIAN WORMS (Turbellaria) 151

HEDGEHOG-SKINNED ANIMALS (Echinodermata)—Common Star-Fish 153

CHAPTER XIV.—THE FOOD OF ANIMALS—ZOOPHYTES, SPONGES, AND PROTOZOA

ZOOPHYTES, &c. (Cœlenterata). Comb-Jellies (Ctenophora)—Cydippe, Beroë. Sea-Anemones and Typical Corals (Anthozoa). Zoophytes, Jelly-Fish, and Millepore Corals (Hydrozoa) 155

SPONGES (Porifera) AND ANIMALCULES (Protozoa) 163

CHAPTER XV.—THE FOOD OF ANIMALS—PLANT-EATING MAMMALS

MAN AND MONKEYS (Primates)—Entellus Monkey 164

HOOFED MAMMALS (Ungulata): Odd-toed Ungulates (Perissodactyla)—Horse, Tapir, Rhinoceros; Even-toed Ungulates (Artiodactyla)—Ruminants or Cud-Chewers—Ox, Goat, Blue-Buck, Giraffe, Okapi, Camel; Hippopotamus 165

ELEPHANTS (Proboscidea) 171

SEA-COWS (Sirenia)—Manatee, Dugong, Rhytina 173

GNAWING MAMMALS (Rodentia): Rabbits and Hares, Dormice and Squirrels, Beavers, Voles, Lemmings and Hamsters, Mole-Rats, Porcupines, Cavies 174

MAMMALS POOR IN TEETH (Edentata)—Sloths 178

POUCHED MAMMALS (Marsupialia): Fruit-eating Marsupials—Typical Phalangers, Koala or Native Bear, Long-snouted Phalanger (a honey-eating form); Herbivorous Marsupials—Kangaroos; Root-eating Marsupials—Wombats 180

CHAPTER XVI.—THE FOOD OF ANIMALS—PLANT-EATING BIRDS, REPTILES, AMPHIBIANS, AND FISHES

Page

BIRDS (Aves): General Characters. Pigeons—Ground-Pigeons (Turtle-Dove, Crowned-Pigeons), Tree-Pigeons (Wood-Pigeon, Stock-Dove, Fruit-Pigeons). Toucans. Crows—Nutcracker, Nuthatch. Finches and Crossbills. Oil-Birds. Parrots—Owl-Parrot, Slight-billed Parraquet, Great Black Cockatoo, Ka-ka and Kea Parrots, Lories and Loriquets - 184

REPTILES (Reptilia): Turtles and Tortoises (Chelonia)—Green Turtle, Land Tortoises. Lizards (Lacertilia)—Iguanas, Sea-Lizard, Galapagos Land-Lizard 191

AMPHIBIANS (Amphibia)—Tadpoles 192

FISHES (Pisces)—Sea-Breams, Beaked Carp 194

CHAPTER XVII.—THE FOOD OF ANIMALS—PLANT-EATING MOLLUSCS

SNAILS AND SLUGS (Gastropoda)—General Characters. Limpets, Land-Snails and Slugs 196

CHAPTER XVIII.—THE FOOD OF ANIMALS—PLANT-EATING INSECTS, ARACHNIDS, AND MYRIAPODS

INSECTS (Insecta): Membrane-winged Insects (Hymenoptera)—Saw-Flies, Giant Wood-Wasp, Turnip Saw-Fly, Gall-Flies, Bees, Wasps, Honey-Ants, Harvesting Ants, Leaf-cutting Ants. Beetles (Coleoptera)—Cockchafer, Sacred Scarab, Click-Beetles or Skipjacks, Pea- and Bean-Beetles, Potato-Beetle, Weevils. Net-winged Insects (Neuroptera)—Termites or White Ants. Straight-winged Insects (Orthoptera). Primitive Wingless Insects (Aptera)—Tassel-Tails and Spring-Tails. Scale-winged Insects (Lepidoptera)—Cabbage White Butterfly, Silk Moth, Small Tortoiseshell Butterfly, Peacock Butterfly. Two-winged Flies (Diptera)—Crane-Flies, Hover-Flies, Drone-Flies. Fringe-winged Insects (Thysanoptera)—Corn Thrips. Bugs (Hemiptera)—Cicadas, Plant-Lice or Aphides, Frog-Hoppers 202

SPIDER-LIKE ANIMALS (Arachnida): Mites—Meal-Mite, Gall-Mites, Money-Spider 217

MANY-LEGGED ANIMALS (Myriapoda)—Millipedes 218

CHAPTER XIX.—THE FOOD OF ANIMALS—PLANT-EATING CRUSTACEANS AND LOWER INVERTEBRATES

CRUSTACEANS (Crustacea)—Countryman-Crab, Robber- or Cocoa-nut-Crab, Chelura, Gribble, Wood-Lice - 220

THREAD-WORMS (Nemathelmia)—Vinegar- or Paste-Eel, Wheat Eelworm 222

CHAPTER XX.—THE FOOD OF ANIMALS—OMNIVOROUS MAMMALS

General Characters. MAN AND MONKEYS (Primates). LEMURS (Lemuroidea) 224

FLESH-EATING MAMMALS (Carnivora): Palm-Civets; Bears—Malayan Bear, Brown Bear, Sloth-Bear; Small Bears—Raccoons, Coatis or Proboscis Bears; Weasels—Badgers, Ratels or Honey-Badgers 226

HOOFED MAMMALS (Ungulata): Swine—Wild Boar, Peccaries 231

GNAWING MAMMALS (Rodentia)—Rats and Mice. MAMMALS POOR IN TEETH (Edentata)—Hairy Armadillo. POUCHED MAMMALS (Marsupialia)—Some Phalangers, Bandicoots, Opossums 234

CHAPTER XXI.—THE FOOD OF ANIMALS—OMNIVOROUS BIRDS AND PRIMITIVE VERTEBRATES

Page

BIRDS (Aves): Crows, Starlings; Geese, Ducks, and Swans; Game-Birds—Quail, Partridge, Pheasant, Peacock, Red Jungle-Fowl, Guinea-Fowl, Turkey, Capercailzie, Grouse; Rails—Land-Rail or Corncrake, Moor-Hen, and Coot; Cranes, Trumpeters, and Bustards. Running Birds—African Ostrich, American Ostriches, Emeu 235

PRIMITIVE VERTEBRATES (Protochordata)—Sand and Mud Swallowing, Ciliary Currents. Lancelets. Sea-Squirts or Ascidians. Worm-like Protochordates—Acorn-headed Worm 243

CHAPTER XXII.—THE FOOD OF ANIMALS—OMNIVOROUS MOLLUSCS, INSECTS, AND CRUSTACEANS

MOLLUSCS (Mollusca): Snails and Slugs (Gastropoda)—Grey Field-Slug, Black Slug. Tusk-Shells (Scaphopoda). Bivalve Molluscs (Lamellibranchia)—Fresh-water Mussels, Cyclas, Sand-Gapers - 247

INSECTS (Insecta): Straight-winged Insects (Orthoptera)—Cockroaches, Earwigs. Membrane-winged Insects (Hymenoptera)—Social Wasps, Bees, and Ants. Two-winged Flies (Diptera)—House-Fly. Scale-winged Insects (Lepidoptera)—Omnivorous Caterpillars 250

CRUSTACEANS (Crustacea): Higher Crustacea (Malacostraca)—Crayfish, West Indian Fresh-water Prawn; Lower Crustacea (Entomostraca)—Barnacles, Copepods, Mussel-Shrimps, Leaf-footed Crustacea 253

LIST OF ILLUSTRATIONS

HALF-VOL. III

COLOURED PLATES

PAGE

KINGFISHERS (*Alcedo Ispida*).
From a Drawing by A. Fairfax Muckley *Frontispiece.*

LION SEIZING PREY (*Felis leo*).
From a Drawing by W. Kühnert 10

BRITISH SEA-SLUGS (*Nudibranchs*) (after Alder and Hancock).
A Study by A. Fairfax Muckley 100

AUSTRALIAN SEA-ANEMONES AND CORALS (after Saville Kent).
A Study by A. Fairfax Muckley 158

ARGENTINE TOUCANS (*Rhamphastus Toco*).
From a Drawing by W. Kühnert 186

BLACK-AND-WHITE ILLUSTRATIONS

	Page
Metabolic Staircase -	3
Digit of Cat	6
Skull of Cat	7
Markings of Cat-like Animals	8
Puma (*Felis concolor*)	9
Cheetah or Hunting Leopard (*Cynælurus jubatus*)	11
Foussa (*Cryptoprocta ferox*)	12
Mampalon (*Cynogale Bennetti*)	13
Spotted or Laughing Hyæna (*Hyæna crocuta*)	14
Jaws of Dog (*Canis*) and Pouched Wolf (*Thylacinus*)	16
A PACK OF WOLVES (*Canis lupus*)	16
Vizcacha (*Lagostomus trichodactylus*)	17
The White or Arctic Fox (*Canis lagopus*) -	18
THE POLAR BEAR (*Ursus maritimus*)	20
Stoats (*Mustela erminea*) and Weasels (*M. vulgaris*) in summer dress	21
Stoats (*Mustela erminea*) and Weasels (*M. vulgaris*) in winter dress	22
Otter (*Lutra vulgaris*)	23
Skulls of Seal and Walrus	25
Killer-Whale (*Orca gladiator*)	26
Dolphin (*Delphinus delphis*)	27
Fresh-water Dolphin (*Platanista Gangetica*)	28
Baleen or Whalebone	30
THE GREENLAND OR RIGHT WHALE (*Balæna mysticetus*)	30
Skull of an Insect-eating Mammal (Hedgehog)	31
Hedgehog (*Erinaceus Europæus*) and Young	32
Common Tenrec (*Centetes ecaudatus*)	33
Cape Golden Mole (*Chrysochloris Capensis*)	34
Garden-Shrew (*Crocidura aranea*)	35
Hairy-tailed Mole-Shrew (*Urotrichus*)	36
Common Mole (*Talpa Europæa*)	36
Star-nosed Mole (*Condylura cristata*)	37
Head of Long-tongued Vampire (*Chæronycteris*) (after Dobson)	38
A Javelin-Bat (*Phyllostoma spectrum*)	39
Great Ant-Eater (*Myrmecophaga jubata*)	41
Marsupial Mole (*Notoryctes typhlops*)	43
Spiny Ant-Eater (*Echidna*)	43

	Page
Head of an extinct Toothed Bird (*Hesperornis regalis*) (after Marsh)	45
A Falcon preying upon Lemmings	46
A Secretary-Bird (*Serpentarius secretarius*) attacking a Snake	47
A Darter (*Plotus*)	49
A Pelican (*Pelecanus*)	50
Gulls and Terns	51
Skua (*Stercorarius*) -	51
Scissor-Bill (*Rhynchops*) hunting	52
Frigate-Bird (*Fregatus*)	53
Red-breasted Merganser (*Mergus serrator*) and Black-throated Diver (*Colymbus arcticus*)	54
Night-jar (*Caprimulgus Europæus*) -	56
Greater Spotted Woodpecker (*Dendrocopus major*) -	58
Common Creeper (*Certhia familiaris*)	59
Blue Roller (*Coracias garrulus*)	60
Crowned Tyrant (*Muscivora regia*) -	61
African Ox-Pecker (*Buphaga Africana*)	62
White-eared Honey-Guide (*Indicator Sparmanni*)	63
Huias (*Heteralocha Gouldi*)	64
Great Butcher-Bird (*Lanius excubitor*)	65
Head of Duck (*Anas boschas*)	65
Yellow Wagtail (*Motacilla flava*)	66
Black-tailed Godwit (*Limosa Belgica*)	66
Curlew (*Numenius arquatus*) -	67
Woodcock (*Scolopax rusticola*) -	68
Hawk-bill Turtle (*Chelone imbricata*) -	72
Chameleon seizing its Prey	74
Tunisian Lizards	77
Poisonous Asiatic Snakes -	78
Skull of Rattlesnake	80
Tongue of Frog extended to secure its Prey	82
Toad catching its Prey	83
Angler-Fish (*Lophius piscatorius*)	85
Deep-sea Angler (*Melanocetus Murrayi*)	86
Cross-section through Electric Eel	87
Saw-Fish (*Pristis antiquorum*)	89
Port Jackson Shark (*Cestracion Philippi*) -	89
Eagle Ray (*Myliobatis aquila*) -	90
Electric Ray (*Torpedo*) -	90
Suctorial Mouth of Lamprey (*Petromyzon*)	91
Hag-Fish (*Myxine glutinosa*)	91
Front End of Nemertine, with Proboscis partly protruded	93
Beaks of Cuttle-Fish (*Sepia officinalis*)	95
A Single Row of Teeth from Radulæ of Carnivorous Snails -	96
The Purple-Shell (*Purpura lapillus*)	97
Barbed Poison-Tooth from Radula of a Cone (*Conus*)	97
A Boring Carnivorous Sea-Snail (*Natica Josephina*)	98
Bivalve Shells bored by Natica	98
Heteropods	99
Foraging-Ants (*Eciton hamata*) on the march -	104
Bird-catching Spider (*Mygale*) threatened by a Sand-Wasp (*Pepsis*) -	106
Newts and Fresh-water Insects	108
Scavenging Beetles -	109
The Ant-Lion (*Myrmeleo formicarius*)	112
Mantis Net-Wing (*Mantispa areolaris*) (after Westwood) -	113
Praying Mantis (*Mantis religiosa*)	117
Flies (*Diptera*)	119
Tsetse-Fly (*Glossina morsitans*)	120
Mouth-parts of a Female Gnat (*Culex*) (after Becher)	121
The Common Flea (*Pulex irritans*) -	122
Mouth-parts of a Tree-Bug (*Cicada*) enlarged -	122
Larva of *Reduvius personatus*	123
A Pond-Skater (*Gerris paludum*) enlarged -	123
A Marine Bug (*Halobates*) (after *Challenger* Report)	124
Spinnerets of Spider (greatly enlarged)	127
A House-Spider (*Tegenaria*) in its Web	129
Hunting Spiders (*Salticus scenicus*)	131
Shield-bearing Centipede (*Scutigera*) (after Buffon)	133
Gastric Mill of Crayfish	136
Hermit Crabs (*Pagurus Bernhardus*)	138
Swift Land Crab (*Ocypus*)	140
Sea-Slater (*Ligia oceanica*)	143
Sea-Mouse (*Aphrodite aculeata*)	147
Structure of Medicinal Leech (*Hirudo medicinalis*) (after Leuckart and Hatschek)	148
Green Bonellia (*Bonellia viridis*)	150
A Triclade Planarian with Pharynx protruded -	152
Beroë -	156
A Sea-Anemone	156
Thread-Cells	158
A Branching Coral	159
A Hydroid Zoophyte (*Tubularia*)	160
Group of Individuals from a Millepore Coral (*Millepora*) (after Moseley)	161
A Compound Jelly-Fish (*Physophora hydrostatica*) (after Haeckel)	162
Grinding-Teeth of Horse (*Equus caballus*)	166
Stomach of Sheep (*Ovis aries*) -	168
The Okapi (*Okapia Johnstoni*) -	170
Grinders of African and Indian Elephants	172
The Indian Elephant (*Euelephas Indicus*)	172
The Dugong (*Halicore dugong*)	174
Hares (*Lepus timidus*)	175
Abnormal Skull of Hare (*Lepus timidus*) -	176

	Page
The Common European Mole-Rat (*Spalax typhlus*)	177
Three-toed Sloth (*Bradypus tridactylus*)	179
The Koala (*Phascolarctos cinereus*)	180
The Long-snouted Phalanger (*Tarsipes rostratus*)	181
The Wombat (*Phascolomys wombat*)	183
Stomach of a Crane	184
The Crossbill (*Loxia curvirostra*)	188
Great Black Cockatoo (*Microglossus aterrimus*)	189
The Kea Parrot (*Nestor notabilis*)	190
West Indian Ring-tailed Iguana (*Cyclura carinata*)	193
Tadpoles	194
Single Rows of Teeth from Radulæ of Plant-eating Sea-Snails	196
A Limpet (*Patella vulgata*) leaving its Scar at Ebb-tide	197
Land-Snails and Slugs	200
Hinder-end of a Saw-Fly (after Lacaze-Duthiers)	204
Rose Gall-Fly (*Rhodites rosæ*) and Bedeguars	204
Honey-Ant (*Myrmecocystus Mexicanus*)	207
A Leaf-cutting Ant (*Œcodoma*) carrying a piece of Leaf (after Poulton)	208
A Bug which mimics a Leaf-cutting Ant and its Burden (after Poulton)	208
The Sacred Scarab (*Scarabæus sacer*)	210
Nut-Weevil (*Balaninus nucum*)	211
Termites or White Ants	212
Heads of Butterflies	214
Jaws of a Millipede (after Koch)	218
Robber- or Cocoa-nut-Crab (*Birgus latro*)	221
Wheat-Eelworm (*Tylenchus scandens*)	222
Palm-Cat (*Paradoxurus typus*)	227
Sloth-Bear (*Ursus labiatus*)	228
Proboscis-Bear or Coati (*Nasua socialis*)	229
Sow and Young of Wild Boar (*Sus scrofa*)	231
Lower Jaw of Pig (*Sus scrofa*), showing Teeth	232
Collared Peccary (*Dicotyles torquatus*)	233
Rook (*Corvus frugilegus*)	236
Brent Geese (*Bernicla brenta*)	238
Corncrake (*Crex pratensis*)	240
Crowned Crane (*Balearica pavonina*)	241
Skull of Hornbill (*Buceros galeatus*), in section	242
Lancelet (*Amphioxus lanceolatus*), feeding	245
Scrobicularia, with siphons and foot protruded	249
House-Fly (*Musca domestica*)	252
Common Crayfish (*Astacus fluviatilis*)	253
Ship Barnacles (*Lepas anatifera*)	254

NATURAL HISTORY

THE FOOD OF ANIMALS

INTRODUCTORY

In the early part of Volume I a brief sketch has been given of the process of digestion, by which food is dealt with within the body, and we shall be chiefly concerned in the present section with the various means by which animals obtain the necessary materials wherewith to repair and build up their bodies. Occasion will, however, be taken to recapitulate some of the essential facts and principles relating to the digestive process.

It has been cynically remarked that life may be summarized in the conjugation of a single verb—the verb "to eat"—in its various moods and tenses:—"I eat, thou eatest, he or she eats", &c., with the terrible converse, "I am eaten, thou art eaten, he or she is eaten", &c. This epigrammatic statement embodies a great deal of truth, for a primary characteristic of living things is the constant necessity for food—the law of hunger. A nugget of gold, or a quartz crystal, may remain for an indefinite time without undergoing any appreciable change, and any addition to its substance which may take place consists in the deposition of fresh external layers, such as one sees in the cross-section of a stalactite. But the essential living part of an animal, that exceedingly complex substance known as *protoplasm*, is extremely unstable, and incessantly undergoing waste by a process of breaking down into simpler substances, the simplest of which—as waste products—have to be eliminated from the organism. Every manifestation of life, whether it be a muscular movement, the formation of a digestive fluid, a thought, or an emotion, involves and is

dependent on this sort of waste. In other words, the chemical changes embraced under the term "waste" furnish the power by which the organism is worked, just as a locomotive is kept going by consumption of fuel, or an electric bell made to sound by the chemical action going on in a battery.

Yet, despite this incessant chemical disintegration in nearly all parts of its body an animal maintains a constant shape and appearance for long periods of time, or, if young, may exhibit those increases in size and weight which constitute growth.

It is therefore evident that waste must be counterbalanced by a corresponding process of renewal, while in such cases as those of a growing child or a fattening ox there is not merely bare renewal, but a formation of new substance, often to a very considerable extent. Increase in size does not, however, consist in the addition of external layers, for the new material must be intimately embodied with that already existing. The raw material from which repair and increase are effected is food, which is worked up by the digestive organs into a suitable condition, those parts of it which are not, or cannot be, digested being cast out of the body as useless.

One of our most distinguished zoologists (the late Professor Milnes Marshall) describes the chemical changes by which the living substance of the body is constantly being built up and as constantly broken down, in a very picturesque way, and his words may well be quoted here:—"This conception of protoplasm, or the living matter of animals and plants, as undergoing incessant change, or metabolism as it is called, is one of much importance. Living protoplasm has been compared to a fountain in which the form remains constant though each component particle of water is in constant movement. In protoplasm, as in the fountain, we distinguish two main processes, an uphill or anabolic process, as the water rises to the crest of the wave, or the food is being built up into the living tissues; and a downhill or katabolic process, as the water falls from the crest back into the basin, or as the living brain, muscle, &c., become broken down into the various excretory products. The uphill or anabolic processes are synthetic, and require or absorb energy. . . . On the other hand, the downhill or katabolic processes are analytic, and are sources of energy. Protoplasm may, to adopt the simile given above, be regarded as the topmost point, the

crest of the physiological wave, consisting of matter in a condition of extremely unstable equilibrium . . ." (fig. 303).

The size, shape, and structure of animals, their habits and distribution, all very largely depend upon the ever-present necessity for food, which indicates its existence by the cravings of hunger and thirst. And it is in the main the radical difference as to food which brings about the striking contrasts in form, structure, and mode of life between animals and plants, especially ordinary green plants, as distinguished from fungi. The food of such green plants is of the simplest kind, consisting, as it does, of the carbonic acid gas of the air, and the water which everywhere permeates the soil and holds mineral salts in solution. A plant is therefore surrounded by its proper food, and has only to stretch roots downwards and leafy stems upwards to obtain it in abundance; for which purpose a branching form, offering a large absorptive surface, is eminently suitable. Nor is a digestive cavity necessary to deal with liquid and gaseous food, so such a cavity is characteristically absent. Since, too, the food is in such near proximity, locomotor powers would be superfluous; and equally unnecessary is a well-developed nervous system to regulate locomotion and, with the aid of special sense organs, place the organism in touch with the outer world. As regards any one of the higher animals the case is far different. "A solution of smelling-salts in water, with an infinitesimal proportion of some other saline matters, contains all the elementary bodies which enter into the composition of protoplasm; but, as I need hardly say, a hogshead of that fluid would not keep a hungry man from starving, nor would it save any animal whatever from a like fate" (Huxley). Being devoid of the green colouring matter called *chlorophyll*, which enables a green plant to use the energy of the sun's rays for building up simple food into complex substances, the animal has to live upon very elaborate food, which can only be obtained from one of two sources, *i.e.* plants or other animals. A broad popular distinction has therefore been drawn between flesh-eating animals, plant-eating animals, and those omnivorous forms which, like ourselves

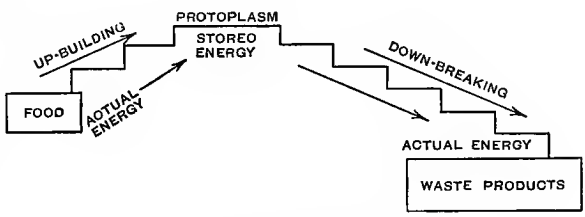


Fig. 303.—Metabolic Staircase

and the pig, affect a mixed diet. A higher animal possesses many characters related to the nature of its food, and contrasting strongly with the relative features of higher plants, as enumerated above. Such are, in particular, a compact shape, an internal digestive cavity, powers of locomotion, and well-developed nervous system with related sense organs.

It will not be uninteresting to consider flesh-eating, plant-eating, and omnivorous animals successively, with special reference to the ways in which they are modified as a result of their proclivities in the matter of food. After this we will briefly review some of the innumerable devices and structural modifications which help animals to escape from those predaceous forms which have developed a gastronomic liking for them.

CHAPTER I

THE FOOD OF ANIMALS—FLESH-EATING MAMMALS (CARNIVORA)—WHALES (CETACEA)

So well marked are the flesh-eating propensities of a large and familiar order of Mammals that they have been christened, *par excellence*, the "Carnivora". Here are included a number of important sub-groups, familiarly exemplified by the Cat, Dog, Bear, and Seal. In many of these forms, however, the diet is not exclusively of animal nature, and some of them take a considerable quantity of vegetable food. Polar Bears in the Zoo are regularly supplied with green meat as an alterative to their fish diet, while loaves of bread are served out to Brown Bears, and every child knows that these ordinary Bruins are particularly fond of honey.

CAT FAMILY

The "harmless necessary cat" is about as typical a Carnivore as can readily be found, and anyone who has observed the stealthy way in which one of these animals approaches small birds, taking advantage of the smallest cover and closing proceedings with a sudden spring, has a very good idea of the way in which Lions, Tigers, and Leopards hunt down their prey. One would expect a Lion, the symbol of British dignity, to adopt tactics of a more open kind, but, as a matter of fact, this does not appear to be the case. As one would anticipate, the muscular system of a Carnivore is exceedingly well developed, the Tiger in particular being very well endowed in this respect, and able to drag along an animal far exceeding him in weight.

The feet and teeth of a Cat will repay close examination, since they are specially modified in accordance with the predaceous habit. To begin with, the animal does not walk on the soles of its feet as we do, but progresses noiselessly on tiptoe,

or, to speak more learnedly, is *digitigrade* (fig. 304). The sharp claws which arm these digits are obviously related to the capture of other animals. To be efficient, however, these weapons must be kept sharp, and hence, when not in use, they are drawn back or *retracted* into special sheaths, being smartly thrust out when the animal strikes its prey. They are kept sharp by scratching against the bark of trees or any handy table-leg. Like our own nails, to which indeed they correspond, they grow continuously throughout life.

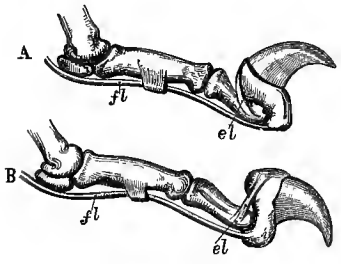


Fig. 304.—Digit of Cat

A, retracted (by elastic band, *el*). B, thrust out (by muscle, of which *fl* is the tendon).

The *teeth* are still more interesting, and are specialized in a very extraordinary manner. To understand the way in which they are adapted to a special purpose, the best plan will perhaps be to first consider the arrangement of our own teeth (see vol. i, p. 35). A complete set of human second or permanent teeth consists of thirty-two members, eight cutting or incisor teeth in front, four pointed canines or eye-teeth, and twenty grinders or cheek-teeth. The number and arrangement may conveniently be expressed by what is called a *dental formula*, as follows:—

$$\text{Incisors} = \frac{2-2}{2-2},\ \text{canines} = \frac{1-1}{1-1},\ \text{grinders} = \frac{5-5}{5-5}\ (\text{consisting of}$$

$$\text{premolars} = \frac{2-2}{2-2},\ \text{and molars} = \frac{3-3}{3-3}).$$

Each fraction represents one kind of tooth, the numerator indicating those of the upper jaw and the denominator those of the lower. The dashes divide the right-hand teeth from the left-hand ones, the numbers in all cases corresponding, as the teeth are symmetrically disposed.

The cheek-teeth are placed under two headings, premolars and molars, which are much alike in general characteristics, though in the human subject each premolar has two rounded projections or cusps on its crown, and is therefore often called a *bicuspid*, while each of the molars has four cusps. The essential difference, however, between these two kinds of teeth is that premolars have predecessors among the temporary or milk teeth, while the molars have not.

The dental formula of the Cat is as follows (fig. 305):—

$$\text{Incisors} = \frac{2-2}{2-2},\ \text{canines} = \frac{1-1}{1-1},\ \text{premolars} = \frac{3-3}{2-2},\ \text{molars} = \frac{1-1}{1-1}.$$

It will be seen that the total number of teeth is thirty, two less than in Man, and that there are more above than below. The eight incisors, being small and pointed, are of comparatively little use in dividing food, but the four canines are large pointed tusks, eminently adapted for seizing and holding living prey, while the cheek-teeth have sharp cutting edges quite unfit for grinding, but very well suited for dividing flesh. This is especially true for what are known as the *carnassial* teeth, which are the much-enlarged first lower molars and last upper premolars (*i.e.* the *third* cheek-teeth above and below, counting from the front). These work against one another like the blades of a pair of scissors. It is also to be noticed that the Cat's lower jaw is united to the skull by a very perfect hinge-joint, which only allows of up-and-down movements without any lateral play. The jaws of a Carnivore consequently form a very perfect apparatus for seizing prey and afterwards dividing up its flesh by a series of snaps. Other noteworthy features are the small spiny projections with which the tongue is covered, converting it into a very efficient rasp of great use in cleaning fragments of meat from bones, and the comparative shortness of the digestive tube, in striking contrast with what obtains in a vegetable feeder. Plant food, in fact, is harder to digest than meat, and a very large surface is necessary by which the digested matters can be absorbed into the blood and lymph systems.

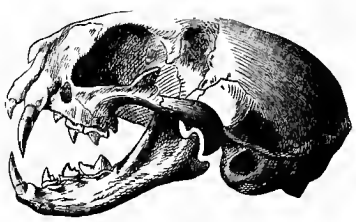


Fig. 305.—Skull of Cat

What is true for a Cat as regards structure is in the main true for all cat-like Carnivores, such as Lions, Leopards, Tigers, and Jaguars. As a general rule, too, these animals are coloured in such a way that they harmonize with their surroundings, and are therefore better able to steal upon their victims without being observed (fig. 306). This kind of coloration is of the kind termed by naturalists *general aggressive resemblance*, which is seen in many groups of widely-differing animals. The conspicuous black and tawny stripes of a Tiger (*Felis tigris*) do not at first

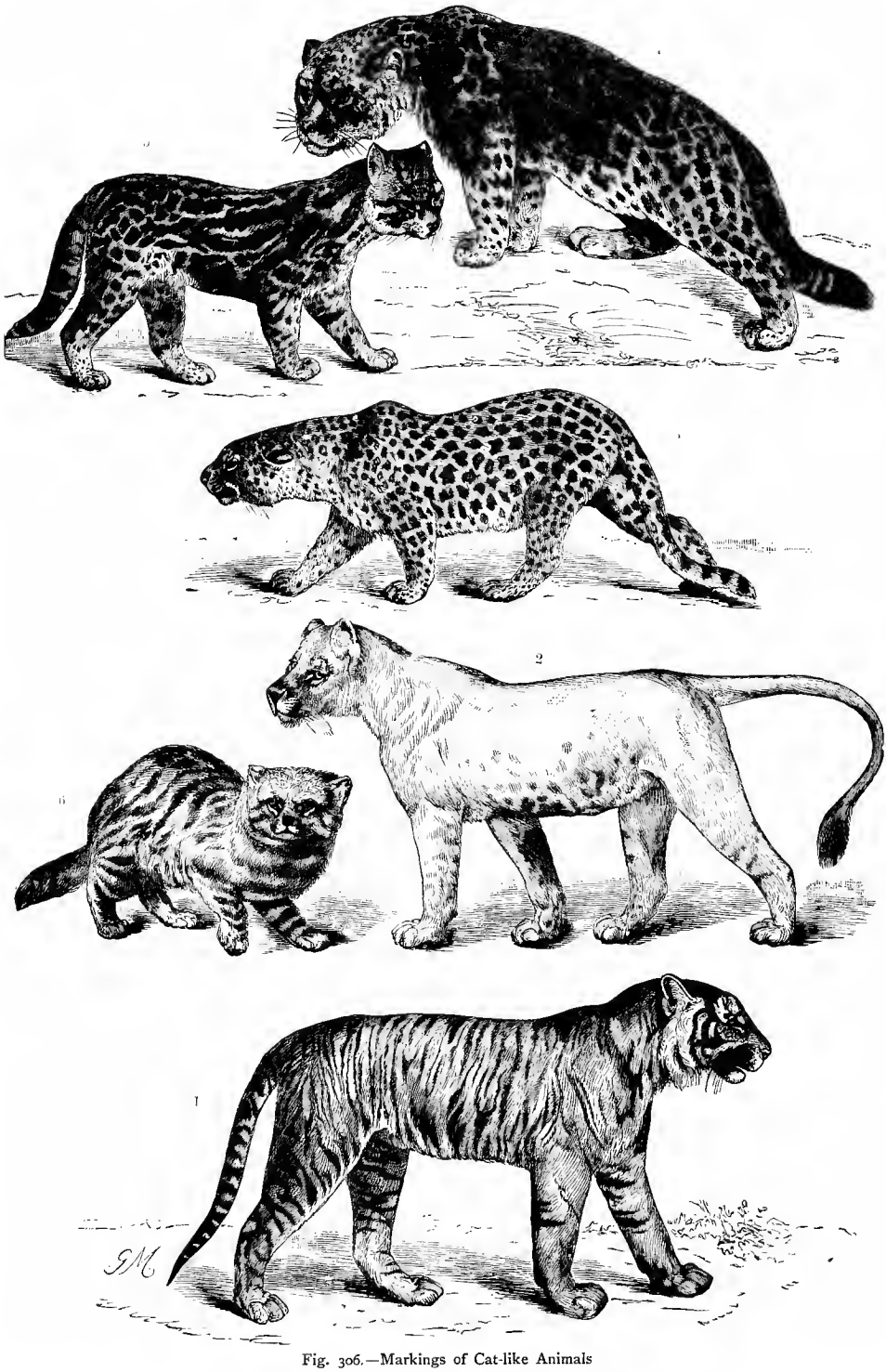


Fig. 306.—Markings of Cat-like Animals

1, Tiger; 2, Lioness; 3, Panther; 4, Jaguar; 5, Ocelot; 6, Pampas Cat.

sight appear to favour concealment, but those who have seen the animal among the reeds and grasses of his native jungle, where patches of light and snade alternate in a confused way, assure us that such is the case.

The tawny colour of the Lion (*Felis leo*) of the Old World, and of the American "lion" or Puma (*Felis concolor*) (fig. 307),

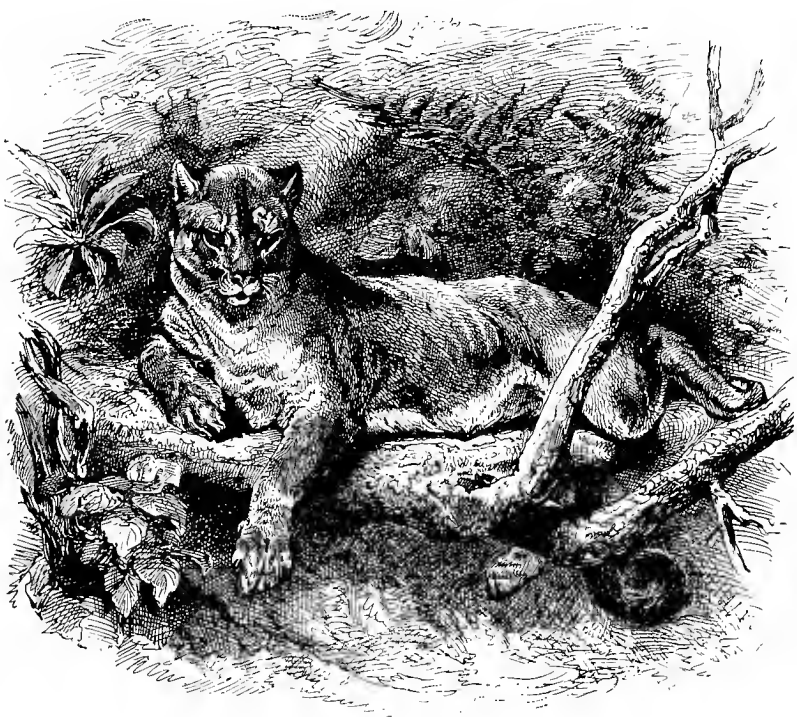


Fig. 307.—Puma (*Felis concolor*)

is also an example of aggressive coloration, harmonizing with the sandy wastes that are more particularly affected by these animals. A similar coloration is characteristic of desert forms belonging to widely diverse groups, though in many cases protection is the object sought. It is a curious fact that Lion and Puma cubs differ greatly in colouring from the adults, for the former are striped and the latter spotted. From this it may reasonably be inferred that these uniformly coloured species are descended from striped and spotted forms, and if this inference be correct it is a good example of the "recapitulation" of the history of the species in the life-history of the individual.

There are many points in the habits of the Puma which are of especial interest. One of them is its reluctance, even when hunted down, to attack man. W. H. Hudson, in his charming book *The Naturalist in La Plata*, writes as follows in this connection:—"It does not attack man, and Azara is perfectly correct when he affirms that it never hurts, or threatens to hurt, man or child, even when it finds them sleeping. This, however, is not a full statement of the facts; the Puma will not even defend itself against man." In spite of this apparent timidity, however, the Puma is a hunter of no mean capacity, and attacks large animals in preference to small. Horseflesh is a particularly favourite article of diet, and introduced horses maintain themselves with such extreme difficulty in the puma-haunted regions of America, that Hudson thinks this throws some light upon the remarkable fact that the wild horses, which were once so common on the American continent as indigenous forms, all became extinct despite the favourable conditions as regards food and climate. The Puma is further of interest as being an example of an animal possessing a wide geographical range, in this case practically the whole of America, and its habits vary according to the nature of the surroundings. For the most part it pursues animals which live upon the ground, but in the forest regions of South America has been seen chasing monkeys among the trees.

While the largest of the Cat Family, *i.e.* the Lion and Tiger, either do not climb at all, or do so to a very small extent, and the Puma is not a thorough-going climber, there are a large number of allied species both large and small which largely extend their sphere of operations by the assumption of a climbing habit. Here are included such forms as the *Jaguars* of the New World, and the *Leopards*, *Lynxes*, and *Small Cats* of the Old. In all these cases the fur is more or less spotted or mottled in such a way as to harmonize with foliage, and render the animals inconspicuous (fig. 306). All the members of the Cat Family so far mentioned, when attacking prey possessed of great powers of speed, mainly rely upon a stealthy approach terminating in a sudden rush or spring; but the *Cheetahs* or *Hunting Leopards* (fig. 308) pursue different tactics. It is true that these long-legged creatures approach to within a reasonable distance of such animals as antelopes or deer by stalking them, but so fleet are they them-

LION SEIZING PREY

Members of the Cat tribe, both small and large, hunt their prey in the same kind of way. First there is a stealthy approach, and last a sudden spring, which commonly secures a victim. The plate represents this final stage in the case of a lion which has been stalking a herd of Sable Antelopes. The so-called "king of beasts" is enormously strong, and literally hurls himself upon his prey, preferring the neck as the point of attack. The first blow of the paws often shatters the cervical vertebræ, causing instant death.



LION SEIZING PREY

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selves that if the first rush should fail they are often able to run down their prey. Cheetahs, indeed, are the greyhounds among the Cats, if such an expression is permissible, and it has been asserted that they hold the record among Mammals for short-distance running.

Most members of the Cat Family subsist chiefly or entirely upon land animals. It is, however, a matter of common know-

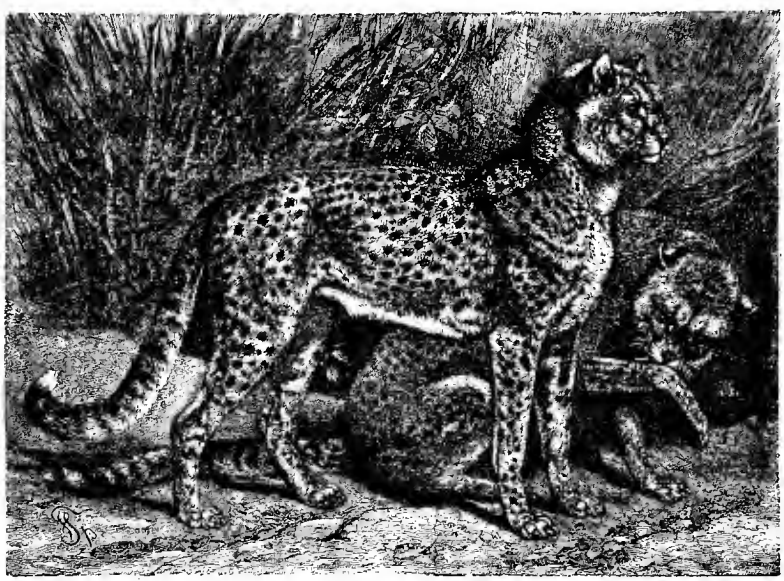


Fig. 308.—Cheetah or Hunting Leopard (*Cynælurus jubatus*)

ledge that domesticated grimalkins are particularly fond of fish, and have even been known to acquire the habit of catching these for themselves. And the large spotted Fishing Cat (*Felis viverrina*) of India and South China largely depends upon this kind of food.

Civet-Cat Family

The Viverrine or Civet-like Carnivores get their living much in the same way as the Cats proper, but, being smaller, attack prey of corresponding size. For this pursuit their long slender bodies, with comparatively short legs and narrow snouts, are well adapted. Viverrines include a large number of widely differing forms, all of which, however, are less specialized than the Felidæ, as seen more particularly in the fact that their teeth are more numerous and less formidable, while their claws are in most cases

comparatively weak. The largest member of the group, and at the same time the least typical, is the Foussa (*Cryptoprocta ferox*), a form peculiar to Madagascar, and probably to be looked on as being a connecting-link with the Felidæ (fig. 309). All the Mascarene Carnivores belong to the Civet group, and by far the most formidable of these is the animal in question. In appearance it

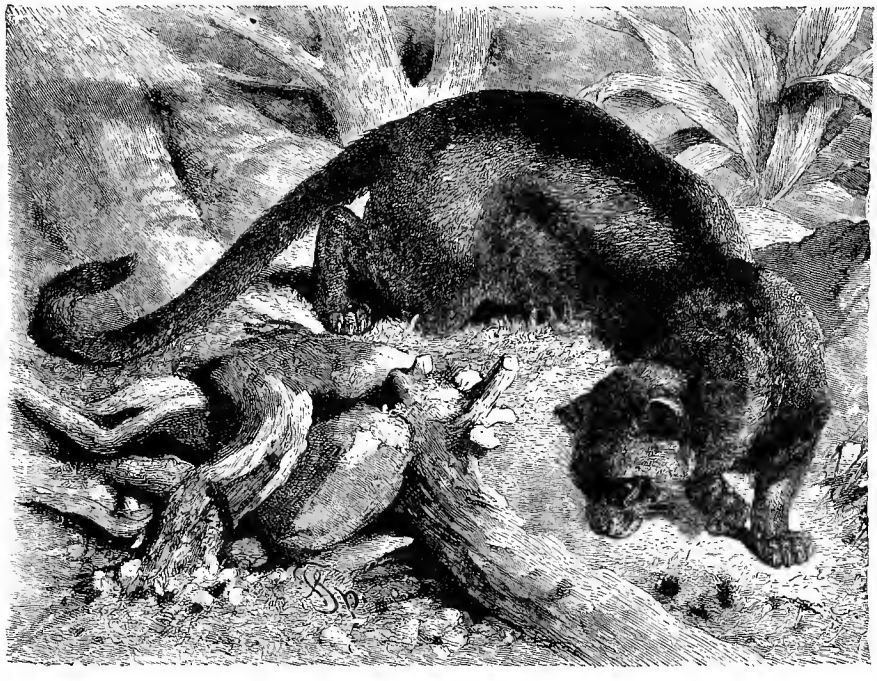


Fig. 309.—Foussa (*Cryptoprocta ferox*)

suggests a cat of slender proportions, and may attain a length of about 5 feet, of which, however, nearly half is taken up by the tail. Little is known of its habits, but it is extremely ferocious, and much dreaded by the natives. Like cats and the like, it is able to pursue prey both on the ground and among the trees. The Civets proper and their immediate allies are characteristic of the warmer parts of the Old World, and some of them are far from being entirely carnivorous in diet. We find here, as among the Felidæ, some species possessed of marked climbing powers, as in the case of the Asiatic Palm-Civets, or Toddy-Cats (*Paradoxures*), the favourite food of which consists of birds, eggs, and small quadrupeds such as rats and lizards. The name of Toddy-Cat has

reference to an almost human frailty displayed by some of these animals. In Ceylon and the south of India the natives are in the habit of suspending vessels from palm-trees in order to collect their sap, which, when fermented, is known as "toddy". Palm-Civets are particularly prone to help themselves to this beverage, with the usual results. The arboreal Binturong or Bear-Cat (*Arctictis*) of North India and South-east Asia, closely related to the Palm-Civets, is of special interest, for its powers of climbing are considerably enhanced by the possession of a grasping or prehensile tail.

All the Viverrines so far mentioned pursue their prey either on the ground or among trees, but fishes and other inhabitants

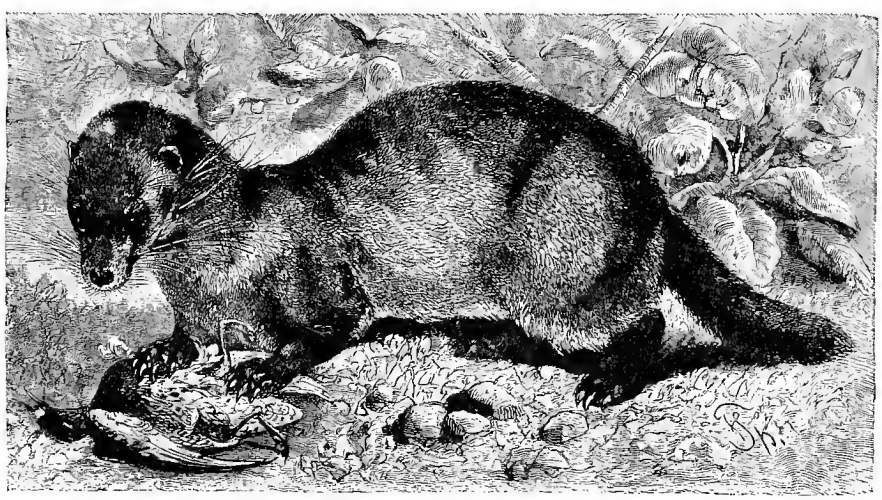


Fig. 310.—Mampalon (*Cynogale Bennetti*)

of lakes and rivers are not exempted from the attacks of animals belonging to this rapacious family. An interesting case is afforded by the Mampalon (*Cynogale*) of Borneo and Sumatra, an otter-like creature with sharply-pointed teeth and partially webbed feet (fig. 310). An expert swimmer, its food chiefly consists of fishes and other aquatic forms, but its resources appear to be considerable, for it is said to climb well, and birds must be added to its extensive dietary, which is also believed to include fruit.

The Mangoustis include those Viverrines which are most unlike the Felidæ, and the most familiar species are those characteristic of Egypt and India. Their food consists mainly of small four-footed animals, birds, and snakes, and though they are

susceptible to the poison of the last-named animals, their extraordinary activity generally saves them from being bitten. Allusion has elsewhere been made to their fabled knowledge of vegetable antidotes to snake-bite, which rests upon no foundation in fact. The Crab-eating Mangousti (*Herpestes urva*) of South-east India, Further India, and South China, is said to be semi-aquatic, and to feed upon frogs and crabs.

Hyæna Family

The Carnivores so far dealt with prey upon living animals, but nothing is wasted in nature, and scavengers are needed to



Fig. 311.—Spotted or Laughing Hyæna (*Hyæna crocuta*)

deal with carrion. To this category belong the unsavoury Hyænas (fig. 311), though they also attack the more defenceless mammals. Their specialized teeth are eminently adapted to a carnivorous diet, and with this specialization goes a reduction in number, as in the Cat Family, though in this case the reduction has not gone quite so far, there being thirty-four teeth as against thirty in the latter family. So powerful are the jaws of Hyænas that they can negotiate skeletons which have been picked clean by other animals, and swallow large quantities of bone in order

to extract the nutriment from it. Regarding this propensity Sir Samuel Baker remarks (in *Wild Beasts and Their Ways*): "The bone-cracking power of this animal is very extraordinary. I cannot say that it exceeds the lion and tiger in strength of jaws, but I can safely assert that both those giants of the feline tribe will leave bones unbroken which a hyæna will bite in halves. Its powers of digestion are unlimited; it will swallow a large knuckle-bone without giving it a crunch. It will crack the thigh-bone of a wild buffalo to obtain the marrow, and will swallow either end immediately after."

The Earth-Wolf or Aardwolf (*Proteles*) of South Africa is a very interesting example of a specialized hyæna which has taken to burrowing (see vol. i, p. 92). The teeth of adult specimens are of peculiar character, for the cheek-teeth are all much alike, and separated by wide intervals. Their crowns are small and pointed, in adaptation to the food, which is said to consist largely of white ants, though no doubt carrion and various small creatures also form part of the diet. The late Mr. A. D. Bartlett, for many years Superintendent of the Zoological Gardens in Regent's Park, after an earth-wolf "had refused pigeon, rabbit, beef, mutton, boiled and raw and chopped in a sausage-machine, and bread-and-milk", at last succeeded in feeding it on "nice fat tripe, well boiled in milk", which suggests that the creature's natural food is of a savoury nature. The study of the first or milk-teeth of the Earth-Wolf brings to light a most interesting case of the Law of Recapitulation (see pp. 9 and 29), for here we find a clear distinction between premolars and molars, while shear-like flesh-teeth or carnassials are present. This and other anatomical facts clearly prove that these animals are descended from forms which resembled ordinary hyænas in structure and habits.

Dog Family

This section of the Carnivora, which includes Dogs, Wolves, Jackals, Foxes, and the like, best represents the average features of the order. The structure of these forms is clearly adapted to the flesh-eating habit, but their teeth and claws are not specialized as weapons of offence to the same extent as the corresponding organs of the Felidæ. Thus the canine and carnassial teeth are well-marked (fig. 312), but not so prominent as in cat-like forms,

and the blunt claws are not capable of being drawn back into sheaths. As might be expected, the teeth are more numerous than in the latter group, their total being generally forty-two as against thirty. Although some of the dog-like animals are carrion-eaters to a greater or less extent, the pursuit of living prey is the rule, and the actions of dogs in a fox-hunt exemplify, under artificial conditions, the normal condition of such animals in a state of nature. That is to say, a number of individuals co-operate together, and the quarry is tracked, mainly if not entirely, by means of the sense of smell. All sorts of Wild Dogs, Wolves, and Jackals hunt together in packs, trusting mainly to their noses, and everyone will recall instances of the kind related in books where the Wolf plays a conspicuous part in the narrative. W. P. Lett (in a section of *The Big Game of North America*) gives the following very good example of the clever tactics pursued by wolves:—"The Madawaska River, which was once, so far as unrivalled natural beauty could make it so, the rushing, foaming queen of Ottawa's peerless tributaries, has along its turbulent course many rapids and chutes of wondrous grandeur and beauty. One of those chutes, about one hundred miles from the city of Ottawa, is called the Wolf Portage. It was so named on account of the wolves chasing deer into the water at that point during winter. The hunted deer were in the habit of rushing into the rapids to escape the fangs of their sanguinary pursuers. In catching the deer at the Wolf Portage, the wolves displayed much cunning. When a deer took to water at the head, it was quickly carried over the rough chute and down the rapids into the gradually narrowing, ice-enclosed glade or channel at the foot. Just at the spot where the current drove it against the ice, under which it would immediately be whirled, a number of the wolves stood on the ice, and the instant the deer touched its edge it was seized by the fierce and hungry animals, dragged out upon the ice,

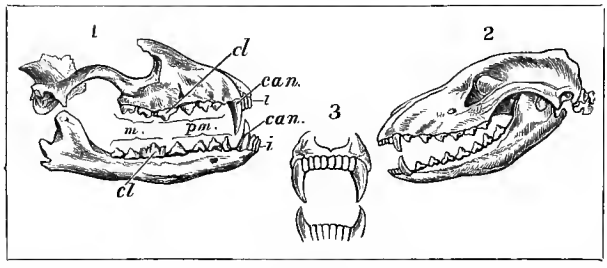


Fig. 312.—1, Jaws of Dog. *m*, Molars; *pm*, Premolars; *cl*, Carnassial; *can*, Canines; *i*, Incisors. 2, Skull of Thylacinus. Note in fig. 3 (representing the front-teeth of Thylacinus) the four incisors in the upper, and three in the lower jaw.

A PACK OF WOLVES HUNTING

The Common Wolf (*Canis lupus*) ranges over the cold and temperate parts of the northern hemisphere, and was formerly abundant in Britain—the last surviving Scottish individuals being killed in 1743, and the last Irish ones even later (? about 1770). The wolves of England are said to have been finally exterminated during the reign of Henry VII. During winter these rapacious carnivores associate themselves into packs, and hunt their prey systematically during the night. These aggressive proceedings are carried out with that kind of skilled division of labour which is characteristic of many social animals. And as in nocturnal flesh-eaters generally, the sense of smell is very strongly developed, constituting the chief means by which prey is tracked.



A PACK OF WOLVES (CANIS LUPUS)

DRAWN FROM THE LIFE BY F. SPECHT

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and devoured. In the early lumbering days upon the Madawaska the skeletons of deer could always be seen in winter lying on the ice at the foot of the Wolf Portage."

Foxes differ in many ways from the other members of the Dog section, hunting, for example, "on their own", and not in packs. Another well-known peculiarity is the habit of living in burrows which have either been excavated by the animals themselves or else are the appropriated homes of other species, such, for example,

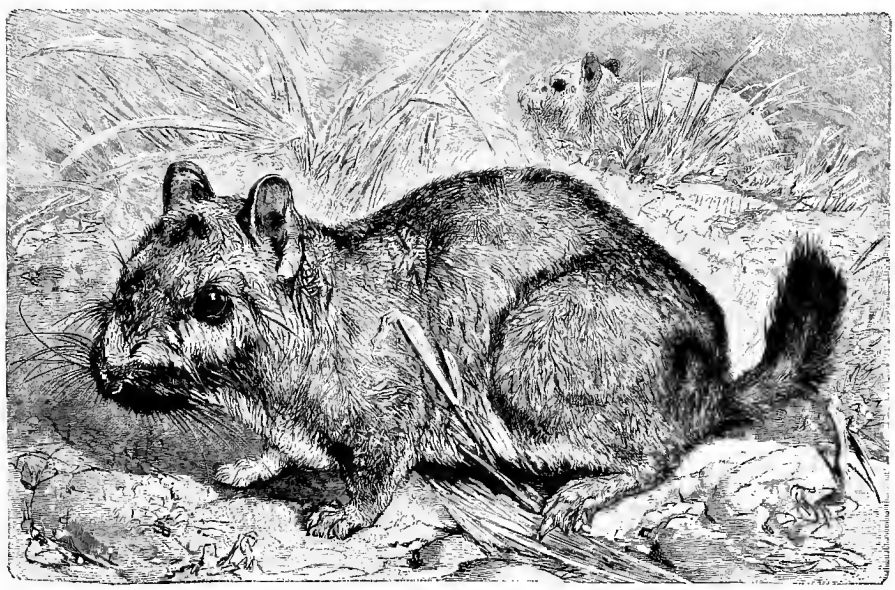


Fig. 313. — Vizcacha (*Lagostomus trichodactylus*)

in this country, as the badger. Cases are also known where foxes share the tenancy with the original proprietors, not always to the advantage of the latter, as the following example will show. The commonest mammal of the South American pampas is the burrowing rodent called the Vizcacha (*Lagostomus trichodactylus*) (fig. 313), which lives in large communities known as vizcacheras. A kind of fox, the Aguarachay (*Canis Azaræ*), inhabits the same regions, and his behaviour towards the Vizcacha is best described by quoting the graphic account given by W. H. Hudson (*The Naturalist in La Plata*):—"The fox takes up his residence in a vizcachera, and succeeds, after some quarrelling (manifested in snarls, growls, and other subterranean warlike sounds), in ejecting the rightful owners of one of the burrows, which forthwith

becomes his. Certainly the vizcachas are not much injured by being compelled to relinquish the use of one of their kennels for a season or permanently, for, if the locality suits him, the fox remains with them always. Soon they grow accustomed to the unwelcome stranger; he is quiet and unassuming in demeanour, and often in the evening sits on the mound in their company, until they regard him with the same indifference as they do the burrowing owl. But in spring, when the young vizcachas are large enough to leave their cells, then the fox makes them his prey; and if it is a bitch-fox, with a family of eight or nine young to provide for, she will grow so bold as to hunt the helpless

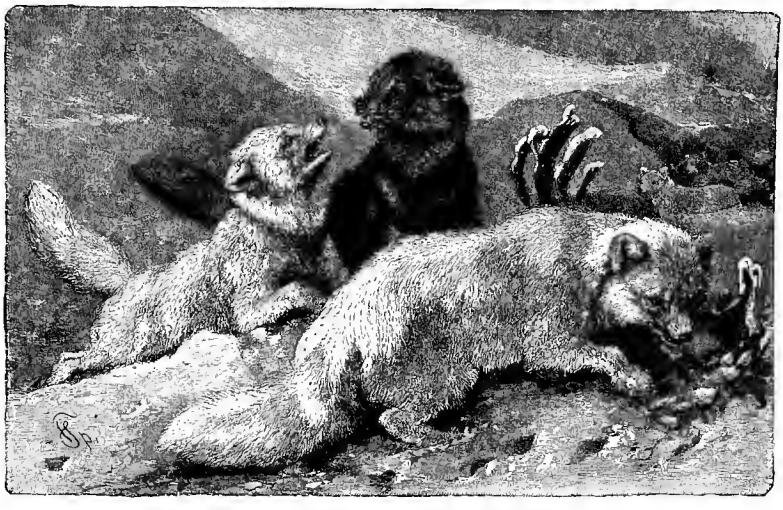


Fig. 314.—The White or Arctic Fox (*Canis lagopus*)

quarry from hole to hole, and do battle with the old ones, and carry off the young in spite of them, so that all the young animals in the village are eventually destroyed."

Foxes furnish good examples of coloration which harmonize with the surroundings, and in this case serve a double purpose, rendering the animals inconspicuous both to their enemies and to their prey, illustrating, therefore, to speak technically, both protective general resemblance and aggressive general resemblance. The Arctic Fox (*Canis lagopus*) (fig. 314), presents this peculiarity in a way which is not infrequent among the inhabitants of the colder parts of the globe, varying in colour according to the season. In summer it is of a gray-brown hue, with a bluish

sheen, which explains the term "blue fox" so often met with in accounts of polar voyages, while in winter it is of a snowy-white. Desert animals make an approach to the desired end of invisibility by means of a uniform fawn or buff colour, and this is the case with the little Fennec (*Canis zerda*), a long-eared fox inhabiting the Sahara (see vol. i, p. 93).

Bear Family, &c.

The last great section of the terrestrial Carnivora is the one which includes Bears and many allied forms. Bears are for the most part very mixed feeders, but the Polar Bear (*Ursus arctos*), which is the largest of them, is essentially a flesh-eater, though it devours vegetable matter to some extent, when such is available. This huge creature is the biggest living Carnivore, and old males have been known to attain a length of over 8 feet and a weight of some 900 pounds. To maintain so vast a bulk means an enormous quantity of food, regarding which Sergeant Francis Long of the Greely Arctic Expedition remarks (in *The Big Game of North America*):—"About four hours each day is the longest time he allows himself for rest from his patient and persevering search for food, for his cavernous maw and his voracious appetite tax his skill and time to keep them supplied with fish and flesh. In his hunt for game the night as well as day is favourable to him, the reflection from the ice at night being sufficient light to enable him to sight and steal upon his prey. The seal is the chief source of food for the Polar Bear, though he also preys upon the walrus and on various fishes." Unlike the Arctic Fox, the Polar Bear is always white or yellowish white, and indeed a change of colour is unnecessary, for he spends his whole time surrounded by snow and ice. This must be looked upon as a case of aggressive general coloration pure and simple, for, excepting man, this monarch of the Arctic regions has no enemies capable of injuring him. In stalking such wary creatures as seals, the inconspicuousness due to the white coloration is invaluable, and the Bear is also greatly helped in this pursuit by the fact that the under sides of his feet are thickly covered with fur, which not only prevents slipping, but also conduces to noiselessness. Marked powers of swimming and diving confer additional advantages. Many accounts have been given of the cunning with which this

animal hunts his chief victim, the seal, and the following quotation from S. M'Tavish (in *The Big Game of North America*) will serve as a typical example:—"Their *modus operandi* of catching the seal is as follows:—The bear having discovered a seal asleep on an ice-floe, immediately slips into the water if he himself be on another ice-floe. Alternately diving and swimming, he approaches close to his victim. Before his final disappearance he seems to measure the intervening distance, and when he next appears it is alongside of the seal. Then, either getting on the ice or pouncing upon the seal as it tries to escape, he secures it." Those who wish a graphic account of the Polar Bear at home should peruse Nansen's *Farthest North*, though this will be superfluous advice for most readers.

Passing by the Raccoons and other Small Bears, which are for the most part as omnivorous as the majority of their larger relatives, the last group of allied terrestrial Carnivores to demand attention is that of the Weasels, which are among the most bloodthirsty animals in existence. The largest species, and one which approaches the Bears in many points, is the Glutton or Wolverene (*Gulo luscus*), an inhabitant of the northerly parts of both Old and New Worlds. The scientific name of this creature is a very good example of the absurdities often involved in such terms. The generic appellation, *Gulo* (Lat. *glutton*), is not very happy, and distinctly slanderous, for though the animal is decidedly voracious it has no claim to be picked out as a type and emblem of excess in the pleasures of the table, though the old zoologists thought so, and promulgated some extraordinary stories on this head, some of which betray a lively though somewhat coarse imagination. But the specific name, *luscus* (Lat. *one-eyed*), is absurd in the extreme, and was given because the first described specimen had accidentally lost an optic. The Glutton is a noted destroyer of many sorts of game, and has even been known to attack reindeer. Significant testimony to his destructive powers is found in the fact that in Norway the same government premium (*i.e.* 20 kroner = about £1, 2*s.* 6*d.*) is paid for his carcass as for that of a bear or wolf. He can both climb and swim, and has a well-earned reputation for cunning, his talents in that direction causing great annoyance to the North American trappers, whose traps he systematically robs. The depredations of the Glutton are much aided by his dull-brown colour and stealthy nocturnal habits,

THE POLAR BEAR (*Ursus arctos*)

The Polar Bear is one of the most rapacious of the flesh-eating mammals, its food consisting largely of seals. These are often captured as the result of combined cunning and patience, the bear waiting for them at the holes in the ice where they rise to breathe. Great powers of swimming and diving largely help in the pursuit of this kind of prey, as also of fishes. The Polar Bear is remarkable in being always white, or yellowish-white, in colour, being thus rendered inconspicuous among its surroundings of ice and snow. This is a good instance of General Aggressive Coloration, whereby an animal which harmonizes with the hue of its surroundings is enabled to approach its prey without exciting premature suspicion.



THE POLAR BEAR (URSUS MARITIMUS)

A STUDY FROM THE LIFE

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all of which help to secure inconspicuousness. Chapman, in *Wild Norway*, writes:—"... One may easily spend years in the haunts of the Glutton without obtaining (in summer) so much as one glimpse of the beast; for he is strictly nocturnal and of secretive habit, lying up all day in the wildest and most rugged corries and rocky glens. I have never myself met with the least evidence of his existence, though hunting forests where we knew him to be."

Badger, Weasel, and Otter Family

The most typical members of the present family are the Weasels, Stoats, Sables, Polecats, and their allies. The Common Weasel (*Mustela vulgaris*) is an abundant British mammal, the

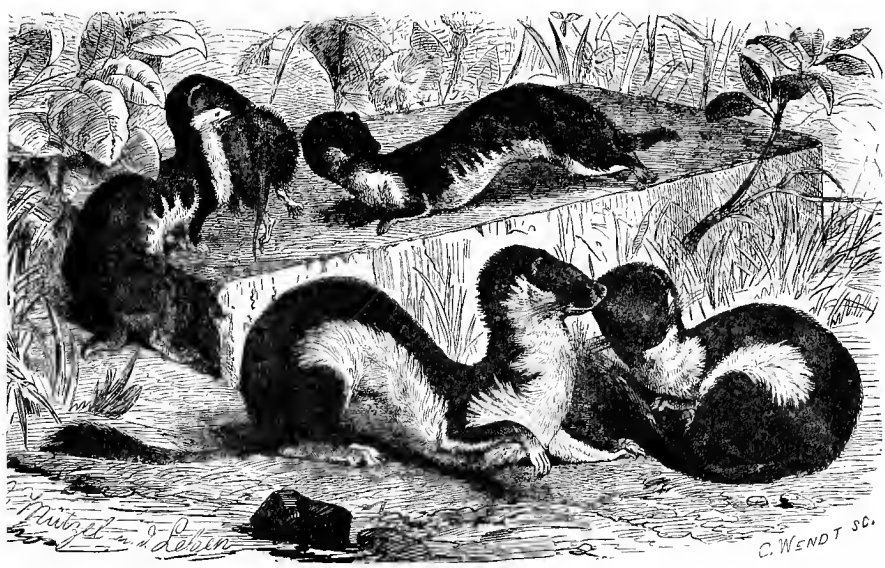


Fig. 315.—Stoats (*Mustela erminea*) in summer dress

extreme alertness of which has become proverbial. It relentlessly pursues all manner of small animals, which vainly seek shelter in narrow crannies or convenient crevices, for their enemy's long neck and narrow sinuous body, with short limbs (see vol. i, p. 97), enable him to follow almost anywhere, while the quarry is rarely his match in point of speed. Added to this, the Weasel is a good climber, so that brooding birds, nestlings, and eggs form an important item in his bill of fare. A number of these animals often hunt together, co-operating with much intelligence for a

common end. Our native Polecat (*Mustela putorius*) is practically a large and relatively clumsy Weasel, which aims at larger game, while the Martens, such as the Pine Marten (*Mustela martes*), a British species, may be looked upon as arboreal Weasels, though they also hunt upon the ground. Mention may be also made of the Stoat or Ermine (*Mustela erminea*) (figs. 315 and 316), the

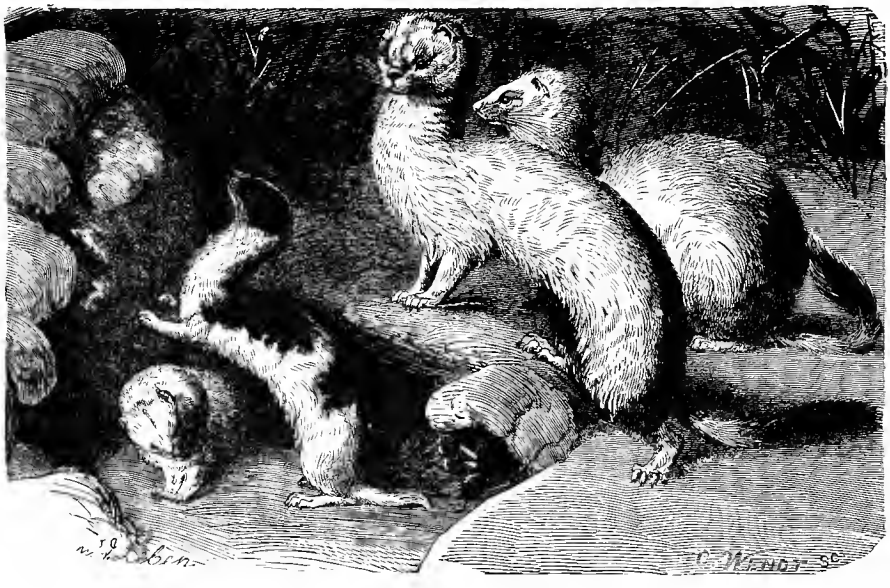


Fig. 316.—Stoats (*Mustela erminea*) in winter dress

characters of which are well expressed by one of its common names, that of "greater weasel". This is one of the forms which change their coats at different times of the year, the winter fur, commonly known as "ermine", being white except for the tip of the tail, which remains jet black. In this way the Stoat is rendered inconspicuous to its prey both in summer and winter.

The Minks of North America, Europe, and Siberia are best described by calling them Water-Polecats, fitted for a semi-aquatic life by the possession of dense fur, small ears, and partly webbed feet. They feed on fish, water-birds, and the like, but also range over the ground which adjoins the banks of their native rivers. From them we naturally pass to the Otters, which form a thorough-going aquatic group of the weasel family. The Common Otter (*Lutra vulgaris*) (fig. 317) is too well known to need much description, and it need only to be noted that its shape

and structure are eminently adapted to the pursuit and capture of fish, which constitute its main food. The flattened head and spindle-shaped body, continued into a gradually tapering tail, flattened from side to side, offer as little resistance as possible to swift passage through the water, and friction is further reduced by the dense smooth fur. The feet are completely webbed, and

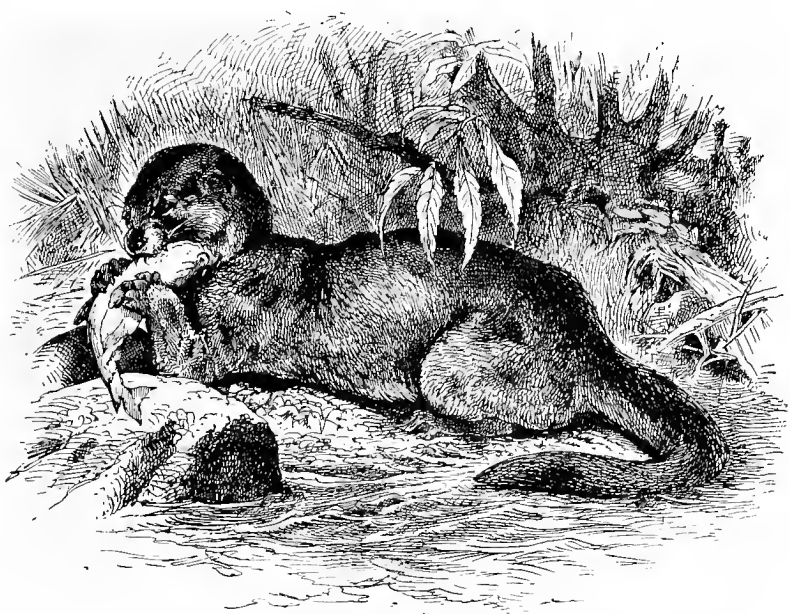


Fig. 317.—Otter (*Lutra vulgaris*)

are largely assisted in their work of propulsion by the powerful tail. The slippery prey, once overtaken, has no chance of wriggling away from between the slender backwardly-curved canines and the sharply-curved teeth by which these are succeeded. Having secured his fish, the Otter holds it between his fore-paws and beginning at the head eats steadily backwards, that is, if really hungry; but in many cases this animal appears to merely hunt for the pleasure of it, and is content with a single bite just behind the back of the fish's head. A small South American species, the Feline Otter (*Lutra felina*), affects a marine habit, and haunts the fjords which abound on the western side of that region. This prepares us for the existence of a thoroughly marine species, the Sea Otter (*Latax lutris*), a large form inhabiting the North Pacific coasts, and attaining the length of 3 feet

exclusive of the tail. This creature looks as if it were on the way to become a sea-lion, especially in the appearance of its head and flipper-like hind-limbs. Its food differs entirely from that of ordinary Otters, as the blunt crushing back-teeth suggest, regarding which H. W. Elliott writes (in *An Arctic Province*):— "Instead of being a fish-eater . . . it feeds almost wholly upon clams, crabs, mussels, and echinoderms or 'sea-urchins', as might be inferred from its peculiar flat molars . . ."

We have now passed in review the most important types of the purely flesh-eating forms of the Terrestrial Carnivores or FISSIPEDIA, and gained some idea of their food and manner of feeding. Before leaving them, a remark is necessary on the powers of sense with which they are endowed. Many of them, as the cat-like forms, have exceedingly acute vision, and their forwardly-directed eyes enable them easily to see prey in front of them. In many cases, too, considerable powers of hearing are possessed, and in order that they may perceive sounds in front of them the ears are usually forwardly directed, for it is well known that the function of the external projection to which the term "ear" is popularly applied has, as its chief function, the determination of the direction from which sounds proceed. Many Carnivores track their prey by means of the sense of smell, and this is particularly true of the dogs and their allies. Otters, too, are exceedingly well endowed in this respect. Nor must the sense of touch be forgotten, to which the characteristic "whiskers" largely minister. These structures are of the greatest use in enabling an animal to perceive the presence of obstacles, and to judge whether a noiseless passage can be made through gaps in undergrowth and the like. Such knowledge is the more important, since the terrestrial Carnivores pursue their prey chiefly during the night, and in many cases even a slight noise would be fatal to success.

Several of the animals already mentioned are partly or entirely aquatic in habit, but the members of the second great group of Flesh-eating Mammals, *i.e.* the Aquatic Carnivores or PINNIPEDIA, are highly specialized for life in the water. They include Seals, Sea-Lions, and Walruses.

In all these aquatic Carnivores the body is shaped so as to promote rapid progression through the water (see vol. i, p. 99), and this is especially true of the Seals proper, which approach

most nearly to the fish-like form. The limbs, too, are modified into webbed paddles, the hinder pair of which are fairly free in the Sea-Lions and Walruses, but in the Seals are backwardly directed and bound up by skin with the tail so as to form a powerful propeller, eminently adapted for rapid swimming, but quite unsuited for movement on land, so that while a walrus or

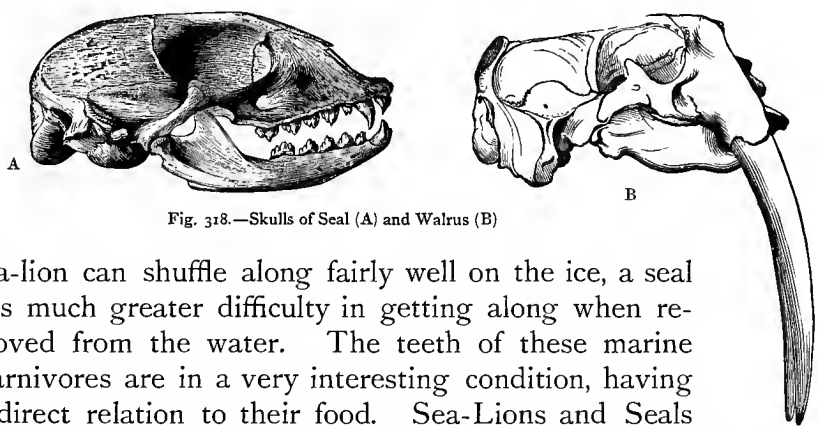


Fig. 318.—Skulls of Seal (A) and Walrus (B)

sea-lion can shuffle along fairly well on the ice, a seal has much greater difficulty in getting along when removed from the water. The teeth of these marine Carnivores are in a very interesting condition, having a direct relation to their food. Sea-Lions and Seals live chiefly on fish, and possess numerous sharply-pointed teeth, well adapted for seizing and holding such slippery prey (fig. 318). Walruses mainly subsist on burrowing shell-fish and other creatures living in mud or sand, and they have a pair of long, tusk-like canines in the upper jaw, by which their food can be dug out of the sea-bottom (fig. 318). These tusks continue to grow throughout life, and in accordance with this do not taper into fangs within the jaw, but project far beyond it. The remaining teeth are blunt and simple, their form fitting them for crushing the food.

PORPOISES, DOLPHINS, AND WHALES (Cetacea)

The Mammals included in this class have become very much specialized to fit them for an aquatic life, and, although their remote ancestors were undoubtedly terrestrial, they have no very near allies among existing land animals. The body is fish-shaped, and suited for rapid progression through the water, propelled by the powerful tail, which is broadened out horizontally (not vertically, as in a fish). The fore-limbs are paddle-like flippers, without external trace of digits, and the hind-limbs are only represented (in

some forms) by a couple of little bones embedded in the muscles, and not to be seen from the outside.

All Cetaceans are carnivorous, and as, in feeding, they are obliged to open their mouths under water, there would be constant danger of choking were there not some special arrangement for preventing water from getting into the lungs. Such a contrivance is here found in the top of the windpipe, which is drawn out into a long cone that fits into the internal opening of the nasal passage. Food can pass back on either side of this cone to the gullet, while at the same time there is no interference with breathing.

Cetaceans are divided as a matter of convenience into Toothed Whales (*Odontoceti*) and Toothless Whales (*Mystacoceti*), which will be considered separately, as their food and way of feeding differ considerably.

TOOTHED WHALES (ODONTOCETI)

Here are included the Dolphin and Sperm-Whale Families, the members of which vary from 6 to 90 feet in length.

DOLPHIN FAMILY (*Delphinidæ*).—The most familiar animal belonging to this family is the Porpoise (*Phocæna communis*) (see

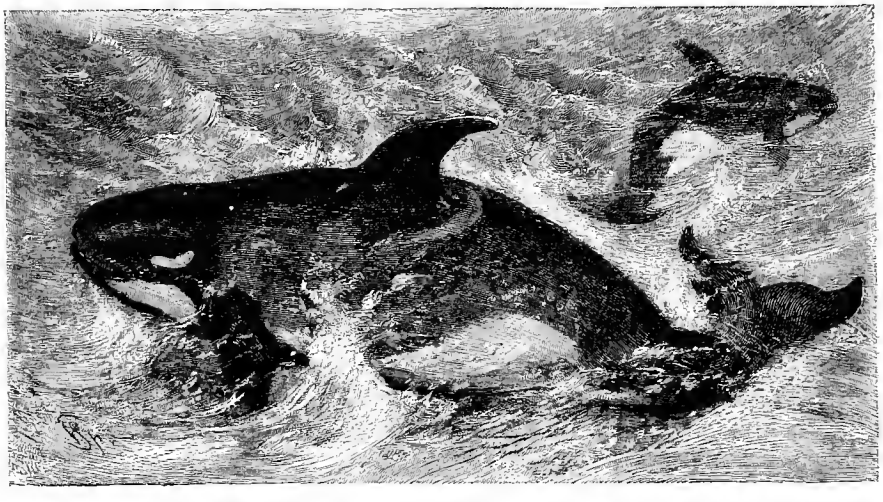


Fig. 319.—Killer-Whale (*Orca gladiator*)

vol. i, p. 100), which is about 6 feet in length, with rounded snout, and jaws armed with about one hundred small sharp, pointed teeth. These are well suited to the nature of the food,

consisting chiefly of fish, which porpoises not only catch in the open sea, but also pursue into estuaries.

The highly predatory Killer-Whale (*Orca gladiator*) (fig. 319) may be as much as 26 feet long, and resembles in appearance a gigantic porpoise. Its propensities are described by Vogt (in *The Natural History of Mammals*) in the following words:— "They are the absolute tyrants of the seas, and work fearful



Fig. 320.—Dolphin (*Delphinus delphis*)

slaughter among the seals and among other cetaceans. Eschricht, a Danish anatomist, who has occupied himself with the Cetacea in a very thorough manner, found a seal sticking in the throat of a killer-whale of about 16 feet in length, which had owed its death to its voracity, since it was prevented from swallowing this seal by having thirteen porpoises and fourteen seals already engulfed in its stomach! The shoals of killer-whales attack the largest cetaceans, and vanquish them. They are said to be peculiarly fond of the fat, fleshy tongues of the whalebone whales." One would rather like to know the collective bulk of the thirteen porpoises and fourteen seals mentioned in the preceding extract. The teeth of the killer-whale are all placed in the front of the mouth, and are forty-four in number. They are of conical shape and backwardly curved.

The Common Dolphin (*Delphinus delphis*) (fig. 320) is rather

larger than the Porpoise (about 8 feet in length), and its snout is drawn out into a short flat beak. The small sharp teeth are often more numerous than those of the Porpoise (up to 200). The habits of this creature are thus described by Vogt (in the work above quoted):—"This dolphin is the animal celebrated by fabulists and depicted by artists, the friend of man, who carries the singer Arion to the shore, renders aid to the shipwrecked, draws the chariot of Galatea, and carries the Tritons and nymphs of the court of Amphitrite. Unfortunately all these virtues have disappeared under the critical eye of modern observers, who no doubt recognize in the dolphin an agreeable travelling companion, who shortens the idle hours of a long sea-voyage by his graceful sporting round the ship, but who, at the same time, is a terribly voracious ravager, who pursues with fury the fastest swimmers

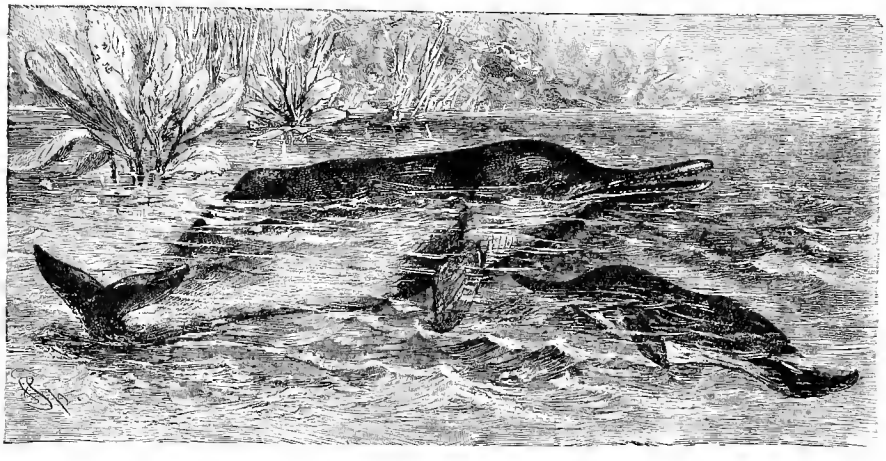


Fig. 321.—Freshwater Dolphin (*Platanista Gangetica*)

among fishes, herrings, mackerel, water-snakes (*Pelamides*), and flying-fish, darting about after them with the most rapid and abrupt changes in his course, and hastening up to a mortally wounded comrade, not to render him succour, as the ancients said, but to devour him."

Fresh-water Dolphins, feeding entirely on fish, live in the rivers of India (Ganges, Indus) and South America (Amazon, Orinoco), and in these the snout is prolonged into a long narrow beak, armed with small teeth, and admirably adapted for seizing and holding the prey. The species figured (fig. 321) is the Gangetic Dolphin or Susuk (*Platanista Gangetica*), which is about 6½ feet

long, and possesses something like thirty-two sharp conical teeth, curved slightly backwards. Those near the front of the beak are larger than the others.

Sperm-Whale Family (*Physeteridæ*).—The largest species here is the gigantic Sperm-Whale or Cachalot (*Physeter macrocephalus*), that rivals in size the toothless whales, attaining as it does a length of 90 feet, of which about one-third is taken up by the huge squarish head. No traces of teeth are to be seen in the upper jaw of the adult, but at an early period of existence vestiges of them are found in the substance of the gum, though not visible externally. The lower jaw is armed with numerous (twenty to twenty-five each side) massive conical teeth, which fit into pits in the upper jaw. The food is said to consist entirely of squids and cuttle-fishes, and huge specimens of the sort are probably more numerous in the open sea than is generally imagined.

TOOTHLESS OR WHALEBONE WHALES (Mystacoceti)

This sub-order includes the largest animals now existing on the earth, sperm-whales alone excepted. The longest of them (up to 115 feet) is the Rorqual of the North Atlantic (*Balænoptera boöps*), but the most familiar species is the Right or Greenland Whale (*Balæna mysticetus*), which, though not so long (80 feet), is much more bulky, and may attain a weight of almost 150 tons. At a very early stage in its existence teeth begin to form in the jaws of this animal (as indeed in the toothless forms generally), but they never cut the gum, and later on all trace of them is lost. No doubt the ancestral forms from which these whales are descended possessed numerous teeth resembling those of dolphins and porpoises, and these useless vestiges are reminiscent of the toothed stage in the history of the sub-order. They afford one of the most striking instances known of the Law of Recapitulation, in accordance with which the development of the individual presents an imperfect epitome of the evolution of the species. It is one of the most extraordinary facts in the whole of zoology that these enormous toothless creatures mainly depend upon very minute animals as food. Floating upon the surface of the ocean are vast assemblages (known as "plankton") of small molluscs, crustaceans, &c., and it is these which are the chief diet of the

Greenland Whale. The teeth have here been superseded in favour of a complex arrangement for catching the diminutive prey, and at the same time for getting rid of the superfluous water.

The capture-apparatus consists of some 400 horny plates, composed of the so-called *whalebone*, which grow down from the roof of the mouth, and are placed in two rows, with their flat surfaces directed to the front and back. The curved inner edge of each plate is frayed out into innumerable slender fibres, which, with the help of the tongue, constitute a very effective strainer (fig. 322). When a sufficiently large mouthful of food has thus been separated from the sea-water, it is swallowed, and the straining process recommences. When it is mentioned that a Greenland Whale 60 feet long is furnished with some 32 cwt. of whalebone, of which the largest plates are as much as 15 feet long, the huge size of this strainer will be appreciated.

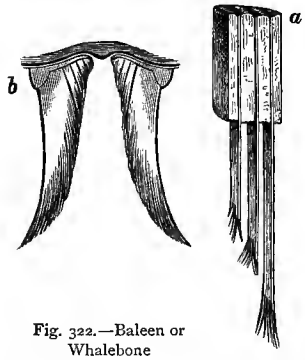


Fig. 322.—Baleen or Whalebone

a, three plates cut through, showing frayed edges; *b*, a pair of plates seen from the front.

THE GREENLAND OR RIGHT WHALE
(*Balæna mysticetus*)

Whales, the largest existing animals, are not fishes, as often supposed, but mammals which have become highly specialized in relation to an aquatic existence. Hence the fish-shaped body, the paddle-like fore-limbs, and the propulsive tail, which is flattened from above downwards and not, as in a fish, from side to side. The hind-limbs are only represented by insignificant vestiges not visible externally. A thick layer of fat ("blubber") is present below the skin, compensating for the practical absence of a hairy external covering. The Greenland Whale, which is the species here depicted, may be over 80 feet long and nearly 150 tons in weight. In spite of its huge size it feeds chiefly upon the shoals of small and minute animals which abound on the surface of the ocean, these being strained through the fringed plates of "whalebone", or baleen, which hang down from the roof of the mouth. Whales rise from time to time to the surface to breathe, a double "blow-hole" on the top of the head representing the nostrils. The "spout" does not consist of water that has passed through the mouth, but is simply the condensed moisture of the breath. The mouth can be kept under water without fear of choking, for the top of the windpipe projects into the back of the nasal passages, and food can pass into the gullet on either side of it.



THE GREENLAND OR RIGHT WHALE (BALAENA MYSTICETUS)

DRAWN FROM THE LIFE BY F. SPECHT

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CHAPTER II

THE FOOD OF ANIMALS—INSECT-EATING MAMMALS

Two orders of Mammals include animals which feed chiefly on insects, *i.e.* the Insect-Eaters proper (Insectivora) and Bats (Cheiroptera).

INSECT-EATERS PROPER (INSECTIVORA)

The Insectivores, or Insect-Eaters proper, are Mammals of small or even diminutive size, which abound in all parts of the world except South America and the Australian region, and are adapted for preying upon insects, worms, snails, &c., while the larger species also attack small vertebrates such as frogs and mice. Since food of suitable kind is to be found not only upon the ground, but also within it and among the trees above it, as also in the waters of the land, we might expect to find, as among the Carnivores, burrowing, climbing, and aquatic species, in addition to forms which run or spring, and this is actually the case.

As becomes Mammals of small size, pursuing prey of corresponding dimensions, the Insectivores are creatures of lowly organization, and their intelligence is small as compared to that of such highly specialized forms as the Carnivores. Their prey being for the most part very active, it is not surprising that they also, as a rule, possess the power of rapid movement, and, since they hunt mostly by smell and sight, their pointed heads are often produced into a long sensitive snout provided with tactile hairs, and bearing the nostrils at its tip. On the other hand, both eyes and ears are often small, and sometimes extremely so. Most of the species do their hunting at night. The numerous teeth (fig. 323) differ strikingly in character from

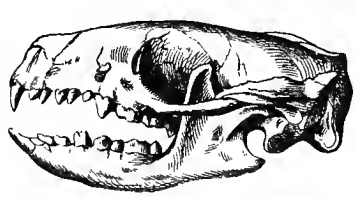


Fig. 323.—Skull of an Insect-eating Mammal (Hedgehog)

those of the Carnivora, exhibiting no prominent tusks or scissor-like carnassials. Both incisors and canines are small and pointed, while the crowns of the cheek-teeth are studded with sharp cusps. Taken as a whole the teeth form a very effective trap for insects and the like.

The Common Hedgehog (*Erinaceus Europæus*) (fig. 324) is a good type of the larger and more sluggish species. Its snout is unusually short for an Insectivore, and its diet is somewhat

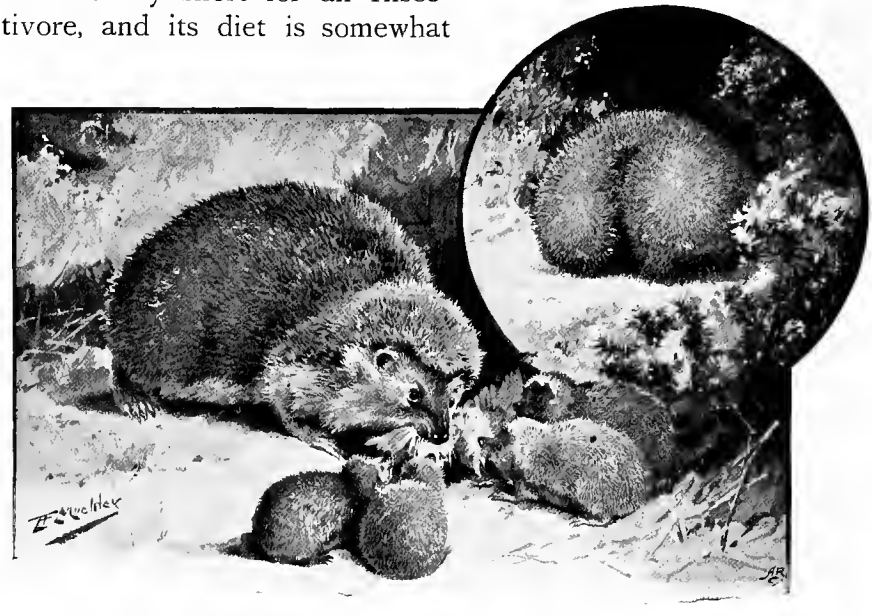


Fig. 324.—Hedgehog (*Erinaceus Europæus*) and Young. A rolled-up individual is shown on the right.

mixed, including not only insects, worms, and other invertebrates, but also frogs, snakes, eggs, small birds, mice, and fruit. Regarding its ability as a mouser Carl Vogt speaks as follows:—"The movements of the Hedgehogs are sluggish, their steps almost tottering, their gait clumsy but noiseless; yet, in spite of this apparent clumsiness and helplessness, the hedgehog is perhaps even better fitted for hunting mice than the cat. It patiently lies in wait for the nimble rodent at the entrance of its hole, and even shows some skill in reaching its prey by burrowing. The noise which it makes in barns, cellars, and stables perhaps helps to drive away the mice; so much, at least, is certain, that places visited by hedgehogs are soon freed from rats and mice and all their kindred." A remarkable peculiarity of the Hedgehog is its im-

munity against animal poisons, being quite unharmed, for example, by the bite of an adder. It is believed to know the difference between poisonous and harmless snakes, for in tackling the former it always begins with the head.

The Tenrecs of Madagascar are relatives of the hedgehogs, but have longer snouts, and present all degrees of spininess down to the entire absence of prickly structures. They are, moreover, of very various size. One of the largest is the Common Tenrec

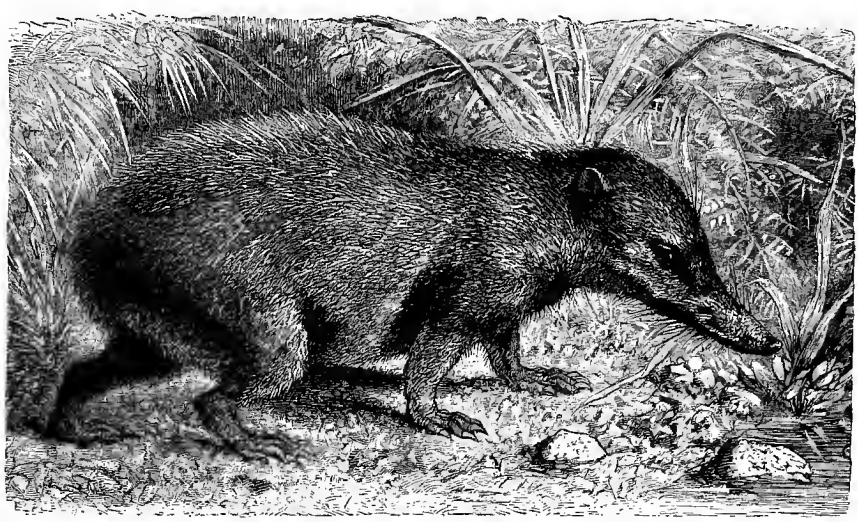


Fig. 325.—Common Tenrec (*Centetes ecaudatus*)

(*Centetes ecaudatus*) (fig. 325), while the small Rice-Tenrecs (*Oryzorictes*) are specially interesting on account of their mole-like form and habits. It is a remarkable fact that the nearest relatives of the Tenrecs are the Agoutas (*Solenodon*) of Cuba and Hayti. In these both snout and tail are much elongated, and the digits are armed with powerful claws. Although little is known of their habits, it is believed that they subsist entirely upon animal food.

The Golden Moles (*Chrysochloris*) (fig. 326) of South Africa, so named on account of their iridescent fur, appear to find their nearest relatives in the Tenrecs, and not in the ordinary moles, as would be naturally imagined. Just as specialization for an aquatic life takes place on similar lines in a number of different groups, so also in the case of burrowing Mammals adapted for the pursuit of earthworms. One marked difference between

a Golden Mole and an ordinary mole is found in the structure of the fore-limb, modified in both cases for digging. In the former there are but three digits, all armed with powerful claws;



Fig 326.—Golden Mole (*Chrysochloris*)

while in the latter there are five digits, similarly provided, and the general appearance is hand-like.

The Shrews include the smallest, most typical, and most widely distributed members of the order. They are exceedingly active creatures, and the more typical species, such as the Garden-Shrew (*Crocidura aranea*) (fig. 327), hunt chiefly on the ground, though they are also able to climb. Burrowing Shrews (*Anurosorex*) have been described from Central Asia and Assam, resembling miniature moles in appearance, and probably with similar habits. A number of Shrews are also more or less modified for an aquatic life, and these exhibit a series of increasing specializations. The Water-Shrew (*Crossopus fodiens*) of Great Britain is a small-eared species which, though not web-footed, is helped in swimming by stiff hairs which project from the under-side of the tail and lower surfaces of the feet. The Swimming-Shrews (*Chimarrogale*) of the Himalayas and Borneo are distinguished by very similar characters. A large amount

of adaptation to an aquatic life has taken place in the Web-footed Shrew (*Nectogale*) of Thibet, where the feet are webbed, and the external ear-flap is entirely absent. The laterally-flattened tail is a powerful aid to swimming. These do not exhaust the list of aquatic Insectivores, though the others to be mentioned do not belong to the family of Shrews. They are the Desmans (*Myogale*), which are included in the Mole Family; and the African River-Shrew (*Potamogale*), which is the type of a special family.



Fig. 327.—Garden-Shrew (*Crocidura aranea*)

The Desmans are remarkable web-footed forms, in which the snout is in the form of an elongated sensitive proboscis used for grubbing about in holes and corners which harbour insect-larvæ and other small creatures. The well-developed swimming tail is long, scaly, and flattened from side to side. One species, the Russian Desman (*Myogale moschata*), which inhabits South-east Russia, attains the length of 16 inches. A smaller species, in which the tail is not flattened, is found in the streams of the Pyrenees.

The African River-Shrew (*Potamogale velox*), an inhabitant of the West African rivers, finds its nearest relatives in the Tenrecs, and may be looked upon as the otter of the Insectivores. It is a large form, reaching a length of 22 inches, of which about half is formed by the powerful laterally-flattened tail, by means of which it is enabled to swim with great rapidity. Not unlike a small otter in appearance, it resembles that animal in regard to its food, which consists of fish.

Some unfamiliar burrowing Insectivores have already been mentioned; the Moles proper and their allies may now be noticed. Certain small species of the Mole Family which have affinities with the Shrews are called on that account Mole-Shrews. The

most typical of these (*Urotrichus*) are found in Japan and North America (fig. 328). These resemble moles more than shrews, but the reverse is the case with a species (*Uropsilus soricipes*)

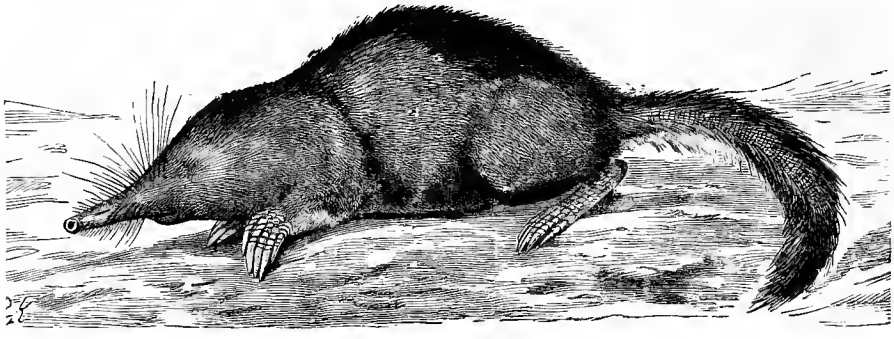


Fig. 328.—Hairy-tailed Mole-Shrew (*Urotrichus*)

found in Thibet. The Common Mole (*Talpa Europæa*) (fig. 329) is a very good instance of an animal which has taken to underground life, and has become modified in accordance with its



Fig. 329.—Common Mole (*Talpa Europæa*)

habits. The limbs are converted into powerful digging organs, while the closely-set velvety fur is not readily soiled by contact with earth. The eyes, being only in the way of such an animal,

are reduced to a very minute size, and are not very perfectly formed.

The Star-nosed Mole (*Condylura cristata*) (fig. 330) of North America differs from the common sort in having a much longer tail, while the snout is encircled by a number of sensitive projections, which probably are of use in detecting prey. The habits of this creature resemble those of ordinary Moles.



Fig. 330.—Star-nosed Mole (*Condylura cristata*)

So far we have considered Insectivores which pursue their prey by running, burrowing, or swimming; but this does not exhaust the possibilities, for there are also arboreal forms, the Tree-Shrews, and leaping species, the Elephant-Shrews.

Tree-Shrews (see vol. i, p. 84), which, by the by, eat fruit as well as insects, inhabit South Asia, and superficially resemble small squirrels in appearance, especially as regards the tail. It is suggested that this resemblance is a case of the well-known phenomenon termed *mimicry*, where a relatively ill-defended animal is more or less protected from the attacks of its foes by being mistaken for some other creature better able to look after itself, or, it may be, possessed of noxious properties. Predatory animals are well aware that squirrels are exceedingly difficult to catch on account of their extreme agility, and it is quite possible that the less active Tree-Shrews lead a life of greater security on account of their squirrel-like appearance. A protective arrangement of the kind is the more necessary since the Tree-Shrews, unlike the rest of their order, feed in the daytime.

The Elephant-Shrews or Jumping-Shrews of Africa (see vol. i, p. 84) are small nocturnal animals with disproportionately long

hind-limbs, and in many cases a proboscis-like snout, which has suggested one of the common names.

BATS (CHEIROPTERA)

The larger Bats are fruit-eaters, but the smaller ones (including all the British species) wage war against winged insects in their own element, the air. These Mammals are very similar to the Insectivora in general structure, their most noteworthy peculiarity being the possession of wings, the structure of which is described

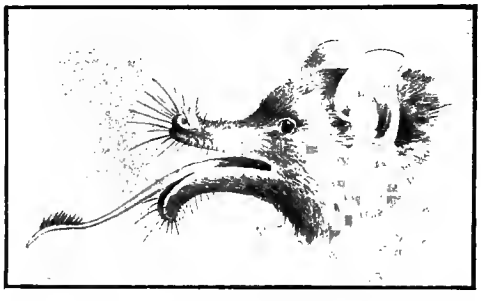


Fig. 331.—Head of Long-tongued Vampire (*Chæronycteris*)

in another chapter, but which differ altogether from the flying organs of birds.

A membrane (interfemoral membrane) stretches between the tail and legs of a Bat, into the hollow formed by which captive specimens have been observed to sweep insects before devouring them. During flight this membrane is concave towards the front, and probably serves as a means of securing prey.

A good deal of the food available for animals is to be found in crevices and small spaces of various kinds, a good example being furnished by the honey secreted in tubular flowers, or in floral nectaries of tubular shape, a secretion which often serves to attract numerous small insects. In various groups of animals the tongue or other mouth-parts have acquired an elongated form, enabling them to secure food hidden away in this manner. Certain South American Bats known as Long-tongued Vampires (fig. 331) are a case in point. In this and a number of other cases the name "vampire" is probably slanderous, there being no proof of a blood-sucking habit. Observations made on captive specimens of some of the species belonging to this group

of Bats have shown that fruit is an important article of diet, but others are known to feed more or less on insects. This is the case with the Long-tongued Shrew-Bat (*Glossophaga soricina*), in which the long mobile tongue has a thick and roughened end. It is exceedingly probable that this organ is used in capturing the small insects harboured in the recesses of flowers, though this may not be its only use, for in an allied form it can be

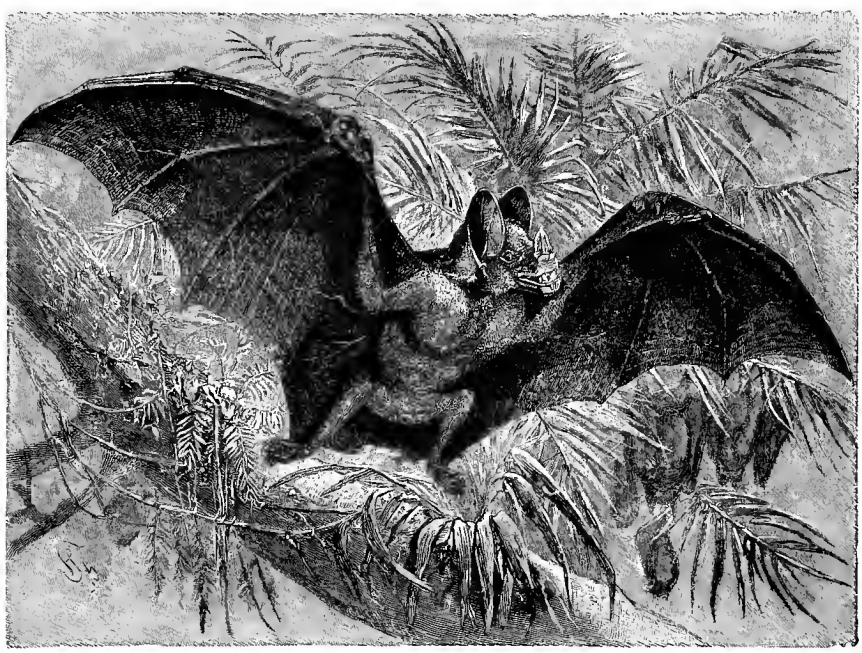


Fig. 332.—A Javelin-Bat (*Phyllostoma spectrum*)

dexterously employed in scraping away the pulp of certain sorts of fruit.

South America is also the home of two species of True or Blood-sucking Vampires. These creatures are provided with sharp-edged incisors, well-developed tusks, and cutting premolars. Darwin actually saw an individual belonging to the larger and commoner species (*Desmodus rufus*) engaged in sucking the blood from one of his horses. The teeth of these creatures are admirably suited for snipping off little bits of epidermis, so as to wound the underlying dermis, which is richly provided with blood-vessels. The stomach of these creatures is modified in accordance with the blood-sucking habit, for instead

of being a broad pouch it is a long narrow tube. An arrangement quite comparable to this is found in other animals which have adopted the same kind of diet. Bates and Wallace both accredit the Javelin Bats of South America with the blood-sucking habit. One species of these (*Phyllostoma spectrum*) is represented in fig. 332.

CHAPTER III

THE FOOD OF ANIMALS—LOWER MAMMALS OF INSECTIVOROUS HABIT—MAMMALS POOR IN TEETH (EDENTATA)

Since more than half the kinds of land animals now living are insects, it is not surprising that these are largely preyed upon by other forms as well as by members of their own class. Amongst the most interesting of insect-eating Mammals, besides those just described, are certain members of the peculiar and

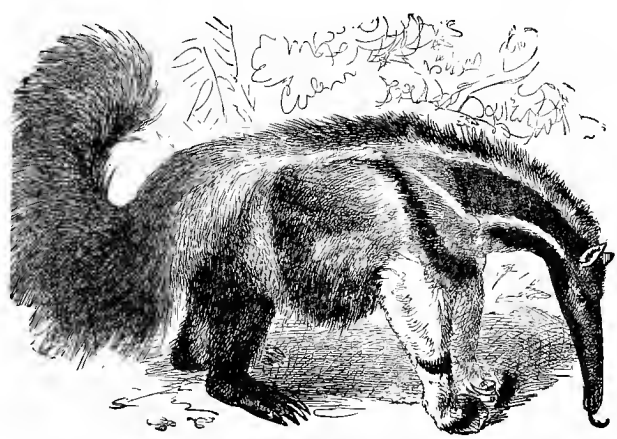


Fig. 333.—Great Ant-Eater (*Myrmecophaga jubata*)

archaic order EDENTATA (*i.e.* Toothless Mammals), rather unfortunately so called, not because they are all entirely devoid of teeth, though this is the case with some, but because front teeth are absent, while it may be added that those present are very peculiar in structure. Edentates include the Great Ant-Eater and the Cape Ant-Eater. The Great Ant-Eater (*Myrmecophaga*) (fig. 333) is a native of South America, and is one of those animals of which it is difficult as a rule to see much in the Zoo, because it spends most of its time curled up in the straw. It is sufficiently

remarkable in appearance, having long hair and large bushy tail, while it walks in a club-footed manner on the outer sides of the hands and feet, which are provided with very powerful claws. In its native state these are used as efficient tools for grubbing among ant-hills and stirring up earth generally. The long narrow snout is well suited for poking into holes and corners, but the method adopted of catching insects is quite different from that found in the hedgehog or shrew. Instead of possessing a close-set array of small pointed teeth the jaws are absolutely toothless, but this deficiency is more than compensated by the presence of a long and exceedingly mobile tongue which, being kept constantly sticky by means of the secretion of large salivary glands, acts like a piece of the best fly-paper.

The Cape Ant-Eater or Aard-vark (*Orycteropus*) is an animal about the size of a small pig, which leads a largely subterranean life in Cape Colony, coming out at night to feed. It has powerful burrowing limbs, and, though possessed of teeth, its sticky tongue, as in the preceding form, is the means by which ants and other insects are captured (see vol. i, p. 137). The same device is found in the related Scaly Ant-Eaters or Pangolins (*Manis*) of Africa and South Asia, much smaller animals, which are largely arboreal, and which are unique among Mammals in the fact that the body is largely covered with overlapping horny scales (see vol. i, p. 138).

POUCHED MAMMALS (MARSUPIALS)

Descending a step lower in the mammalian class we come to the Pouched Mammals, or Marsupials, of which the most familiar example is the kangaroo, and which, with the exception of the American Opossums and one other form (*Cœnolestes*), are now limited to Australia and some of the adjacent islands. The Marsupials present an interesting example of a group of animals which, having been long shut up in a large area presenting a great variety of physical conditions, have, in the absence of more highly organized competitors, become modified along various lines to suit these various conditions. We thus find in Tasmania a Native Wolf (*Thylacinus*), which, in its structure and habits, resembles a member of the much higher group of Carnivora (see fig. 312), while the Banded Ant-Eater (*Myrmecobius*) is adapted for catching insects much in the same way as the Great

Ant-Eater, and the little springing Bandicoots (*Perameles* and *Chæropus*) may be compared to the Elephant-Shrews. The most

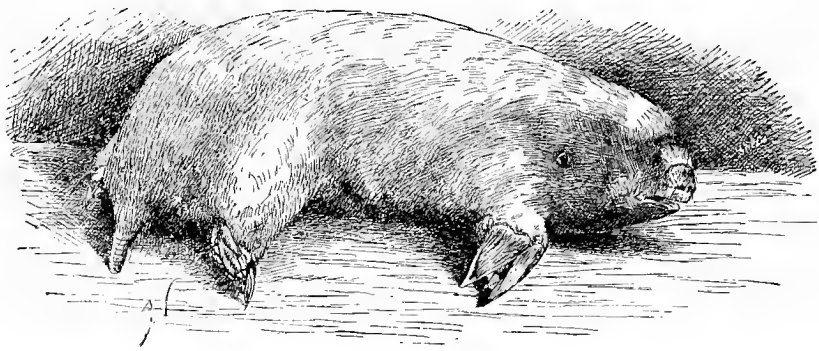


Fig. 334.—Marsupial Mole (*Notoryctes*)

recently-discovered member of the group is the Marsupial Mole (*Notoryctes*) (fig. 334), a small creature that pursues its way

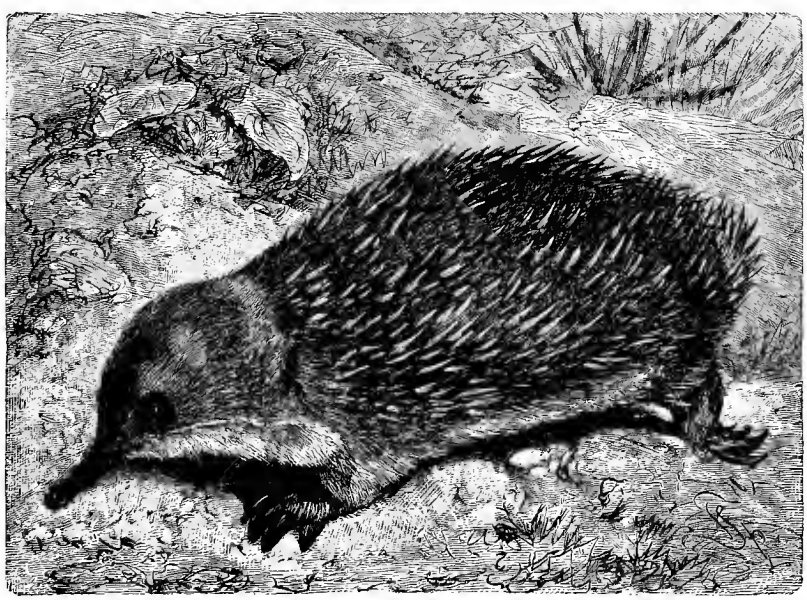


Fig. 335.—Spiny Ant-Eater (*Echidna*)

underground like the British mole, which it superficially resembles. Yet anatomy shows that these three forms are more closely related to one another and to the herbivorous kangaroos than they are to the members of any other mammalian orders.

EGG-LAYING MAMMALS (MONOTREMES)

Australia (with New Guinea and Tasmania) is also the home of the very lowest existing Mammals, the egg-laying Monotremes, of which there are three kinds, the Duck-Mole or Duck-billed Platypus (*Ornithorhynchus*), limited to the Australian continent, and two Spiny Ant-Eaters, of which the commoner, *Echidna* (fig. 335), ranges from New Guinea to Tasmania. Echidna, with its narrow, toothless snout, mobile tongue, well-developed salivary glands, and powerful digging claws, presents an insectivorous type of structure with which we are now familiar.

Comparison of the various insect-eating Mammals shows that similar habits are associated with similar peculiarities of structure, and this furnishes a good instance of the same kind of classificatory pitfall as the one which led the old zoologists, and still leads the unskilled observer, to consider the whale as a fish. Naturalists are now beginning to doubt the propriety of grouping the old-world Edentates with those of the new, and it has been proposed to create a new mammalian order—the Effodientia (*i.e.* Diggers)—for the reception of pangolins and aard-varks.

CHAPTER IV

THE FOOD OF ANIMALS—CARNIVOROUS BIRDS

Birds present many interesting arrangements connected with the capture of different sorts of living prey, pursued on or in the ground, in the water, or in the air. A familiar negative character of these animals is the absence of teeth, a character which, as we have seen, is shared by some Mammals. Birds, however, were not always toothless, the most ancient fossil forms known being comparatively well off in this respect. As a good example we may take Hesperornis (fig. 336), from the chalk rocks of North America, which lived at a time when the dominant back-boned animals were Reptiles. It was a large bird, measuring nearly 6 feet from the tip of the bill to the ends of the toes, and its wings were in an undeveloped condition. This, however, was fully made up for by the powerful legs and feet, which made it an expert diver and swimmer, while the long bill, probably sheathed with horn at its tip, was armed with numerous simple pointed teeth, placed in grooves, and with their points directed backwards. Hesperornis undoubtedly lived on fish, and its long toothed jaws would be well suited for dealing with prey of that kind.

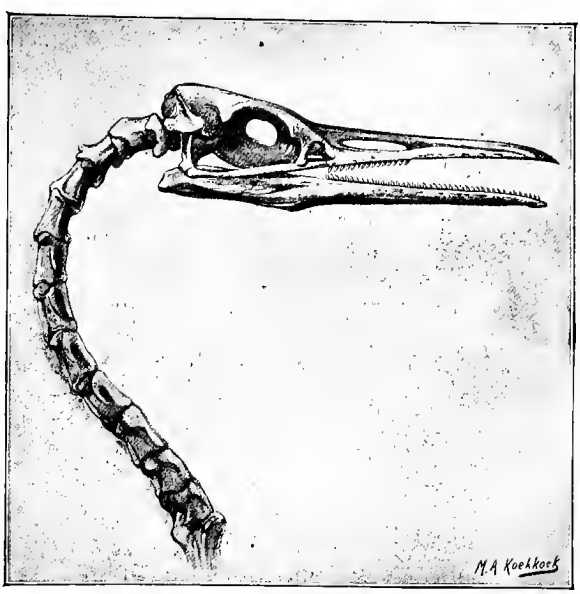


Fig. 336.—Head of an extinct Toothed Bird (*Hesperornis regalis*)

BIRDS OF PREY

Among living birds some of the most notable groups are those which include Birds of Prey, such as eagles, falcons, hawks, and owls, and the structural features enabling them to catch small Mammals, other birds, reptiles, or fish are sufficiently obvious.

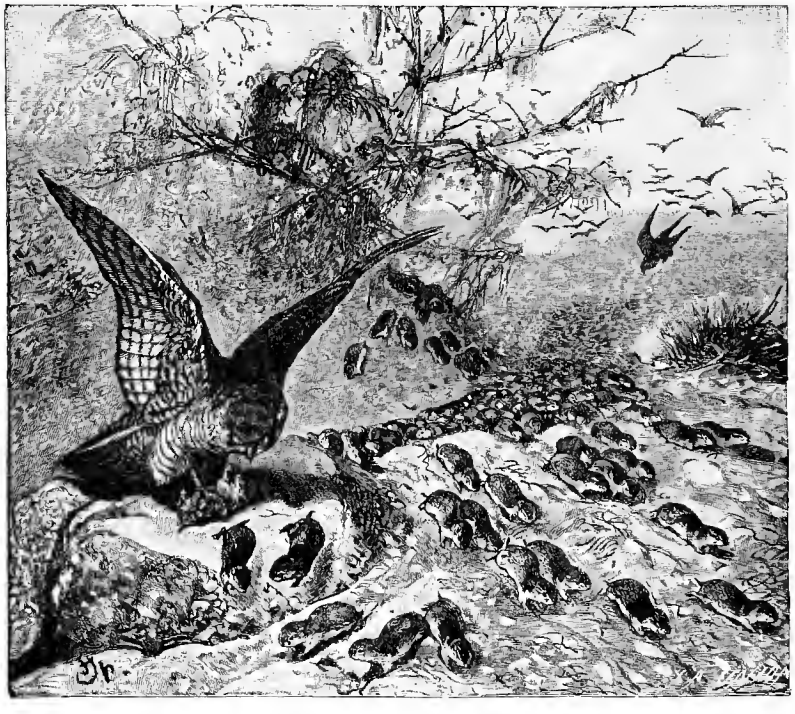


Fig. 337.—A Falcon preying upon Lemmings

Take, for example, any sort of Falcon (fig. 337). Here we find great powers of rapid flight, a strong hooked beak, and well-separated toes provided with large and sharp talons, which have been compared to grappling-irons; add also very perfectly-constructed eyes and remarkably keen sight. Three toes are directed forwards and one backwards. In Owls the large eyes are suited for making the most of a feeble light.

A very interesting bird of prey possessed of long legs and webbed feet, quite unlike those of the preceding, is the Secretary Bird (*Serpentarius*) found in South and East Africa (fig. 338). It feeds upon many kinds of reptiles, especially snakes, on which

account it is protected by the local governments. The following account, taken from Verreaux, describes in a spirited manner the bird's tactics when attacking a snake:—"As nature exhibits foresight in all that she does, she has given to each animal its means of preservation. Thus the Secretary Bird has been modelled on

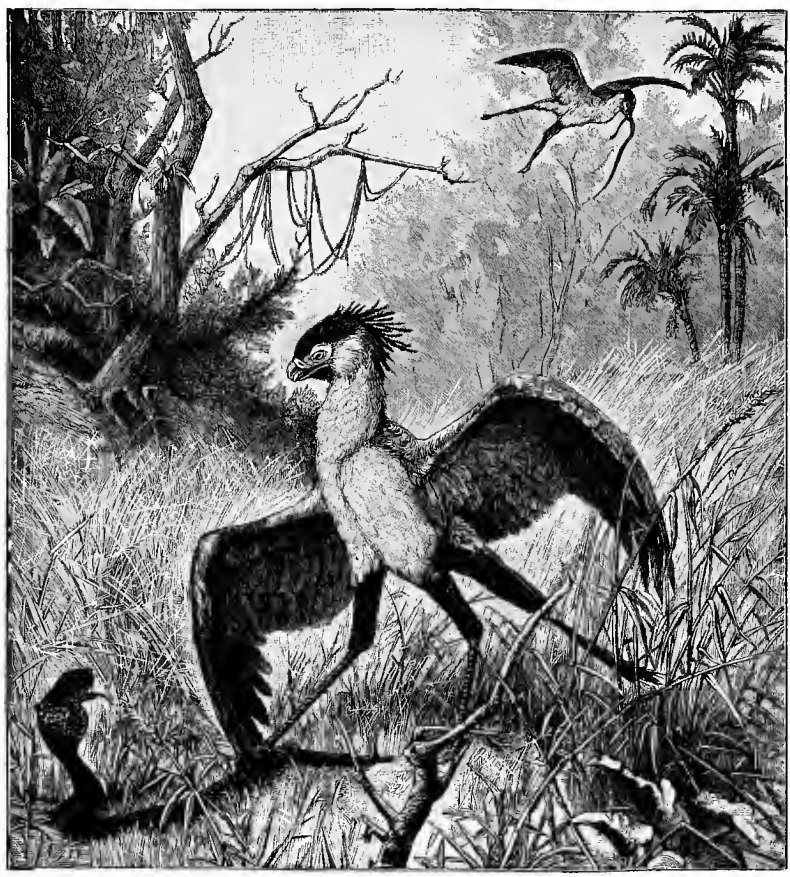


Fig. 338.—A Secretary-Bird (*Serpentarius secretarius*) attacking a Snake

a plan appropriate to its mode of life, and it is therefore for this purpose that, owing to the length of its legs and tarsi, its piercing eye is able to discover at a long distance the prey which, in anticipation of its appearance, is stretched on the sand or among the thick grass. The elegant and majestic form of the bird becomes now even more graceful; it now brings into action all its cunning in order to surprise the snake which it is going to attack; therefore it approaches with the greatest caution. The elevation of

the feathers of the neck and back of the head shows when the moment for attack has arrived. It throws itself with such force on the reptile that very often the latter does not survive the first blow." The author then goes on to describe the skilful way in which the bird avoids being bitten by the snake if the first attack is unsuccessful, using its wings as a kind of shield and its powerful feet as the chief weapons of offence.

Some raptorial birds feed chiefly on fish, as in the case of certain owls which hunt their prey in rivers, ponds, and canals, while the widely-distributed Osprey or Fishing-Eagle (*Pandion*) swoops down on sea-fish which come sufficiently near the surface, holding them by its powerful talons aided by the roughened under-surfaces of its feet.

FISH-EATING BIRDS

Raptorial birds, whatever may be their prey, rely upon their mobile and powerfully-armed feet for its capture, but in other cases the beak is the seizing organ, its shape varying according to the kind of food, which also determines the nature of the hunting tactics. A number of very interesting cases are presented by fish-eating birds. In these the beak is strong, pointed, and commonly with its edge more or less saw-like, so as to securely hold the slippery prey (compare Hesperornis, p. 45), or, for the same reason, it may be hooked at the tip. Marked powers of locomotion are the rule, and the vision is keen. Cormorants, of which there are two native species, the large Black Cormorant (*Phalacrocorax carbo*) and the smaller Green Cormorant or Shag (*P. graculus*), are good examples of fishing birds. Perched on some convenient spot close to the water, they pounce suddenly down upon their victims; but this is by no means their only or even chief resource, for, being extremely expert swimmers and divers, they pursue fish on more than equal terms in the water, a favourite habit being to swim swiftly with their heads submerged.

A small Green Cormorant (*P. Capensis*), closely allied to the last-named bird, is common on the coast of South Africa, and Millais (in *A Breath from the Veldt*) gives the following interesting account of its feeding habits:—"Should the traveller be so disposed, an interesting sight may be witnessed any day by

watching these little cormorants fishing. Their more ordinary method is that of singly diving in the shallows, after the manner of all their species. But instinct and an excessive abundance of their natural food has taught these birds that by uniting their forces a full stomach may be obtained with far less trouble than the methods they usually employ. The plan resorted to is as follows; and with the exception of one species of North African pelican, it is one that is not followed by any other sea-bird that I know of:—The cormorants to the number of ten or twenty form line, each bird being within a couple of feet from its neighbour, and swim along the shore at right angles to the beach, the bird nearest the land being only just able to float. In this manner they advance, constantly inspecting the water beneath by immersing their heads and necks until a shoal of small fish is found. Then the whole line wheels, as it were, at once shorewards, most of the birds diving together in shallows, thus frightening the fish, which escape before them in such quantities that a large number are forced right out of the sea on to the beach itself. These tactics are generally rewarded by a plentiful repast, each bird resting on its breast amid the stones, and gobbling up the fish as they spring on all sides, attempting to regain their natural element."

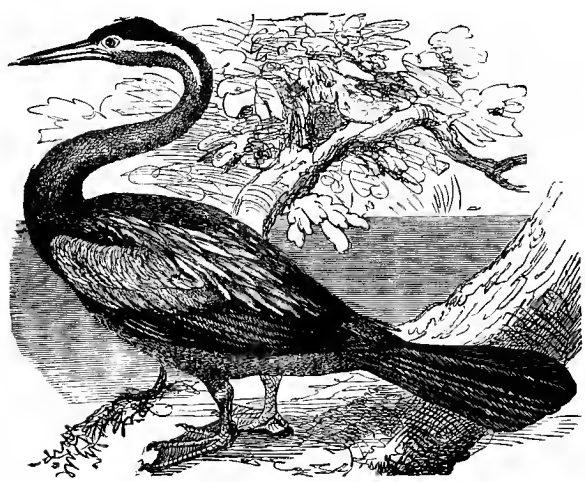


Fig. 339.—A Darter (*Plotus*)

The Darters, or Snake-Birds (*Plotus*), of Africa, South Asia, South America, and Australia, may be described as fresh-water cormorants. They are distinguished by exceedingly sharp, slender beaks, and a narrow, swan-like neck (fig. 339). These structural features are directly related to the habits. One of these birds has been observed swimming under water in pursuit of a fish, which was ultimately bayoneted by a thrust from the beak, in making which the neck was suddenly straightened. The bird

then rose to the surface with its prey, which was jerked off and caught in the mouth.

The Gannet (*Sula Bassana*), a British form, follows quite a different plan of campaign from the closely-allied cormorants. It flies about till a fish is seen, and then, rising to a certain height above it, drops suddenly down, and usually secures it.



Fig. 340.—A Pelican (*Pelecanus*)

Pelicans (fig. 340), which are allied to cormorants and gannets, abound in the warmer parts of the globe, and hunt fish in the shallower parts of rivers and estuaries, swimming with their heads under water. Like the Cape Cormorant, these birds have learnt the value of co-operation, for they commonly hunt together in long lines, a proceeding disastrous to their prey. Everyone knows that the Pelican possesses a convenient pouch hanging down from the lower part of the beak, and serving as a fish-basket.

Gulls and Terns (fig. 341) haunt the coasts of most parts of the world, and are good swimmers and flyers, though otherwise they present no features of striking character. It is a matter of common observation that some gulls are by no means limited to a fish diet, for they may often be seen some distance inland searching for worms and other small creatures. And while some of the terns are coast birds, others haunt rivers, feeding not only upon fish, but also on insects, leeches, and the like.



Fig. 341.—Gulls and Terns

Though closely related to the gulls, Skuas (fig. 342) in some respects remind one of the birds of prey, for their powerful beaks are hooked, and, contrary to the general rule, the webbed feet are provided with strong talons. These features, however, must not be taken to mean affinity with raptorial birds, being simply an adaptation to somewhat similar habits. The prey consists of fish, small marine birds, &c., which are held firmly by the strong claws. Their piratical habits are well known, for they mostly take advantage of the industry of gulls and terns. If, for instance, a skua observes that a gull has caught a fish, the result will probably be a spirited chase, resulting in the abandonment of the just-swallowed prey by the frightened victim. Upon this the pirate skua immediately pounces, often securing the

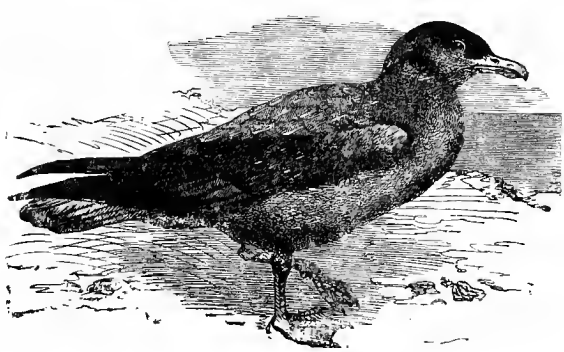


Fig. 342.—Skua (*Stercorarius*)

ill-gotten booty before it reaches the water. These birds inhabit the colder parts of the world, but Richardson's Skua (*Stercorarius crepidatus*) is pretty common in the extreme north of Scotland. Other species are also known. R. Kearton (in *Wild Life at Home*) gives an interesting photograph of a Great Skua or Bonxie (*S. catarrhactes*) attacking a watcher who has approached the nest. This was taken on the island of Unst, in the Shetlands.

Scissor-bills or Skimmers (*Rhynchops*) constitute a small group of gull-like birds, inhabiting North America, Egypt, and India.

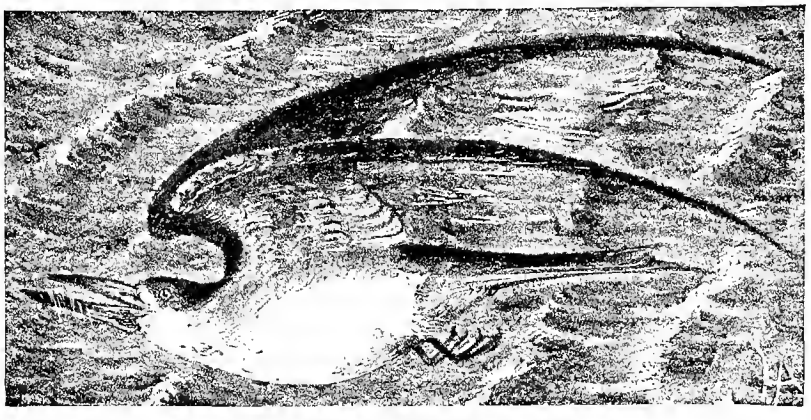


Fig. 343.—Scissor-Bill (*Rhynchops*) hunting

The common names have reference to the structure and action of the long compressed beak, of which the lower half projects considerably beyond the upper portion. The Scissor-bills skim along close to the surface of the water with the lower part of the beak immersed, and the upper mandible can be worked up and down so as to secure any small fishes which are so unfortunate as to find themselves skimmed on to the projecting part of the beak (fig. 343).

Some marine birds are pelagic in habit—that is to say, are found far from land, where they play havoc among the finny tribes. The most notable of these are the Frigate-Birds, Albatrosses, and Storm Petrels, all of which have hooked beaks and possess considerable powers of flight. The Frigate-Birds (fig. 344) are related to the pelicans, and include the Great Frigate-Bird (*Fregatus aquila*) of the Atlantic, Pacific, and Indian Oceans, and the Lesser Frigate-Bird (*F. minor*), from the last

two of these. H. O. Forbes (in *A Naturalist's Wanaerings in the Eastern Archipelago*) describes the piratical habits of the smaller species, which pursues tactics much like those already mentioned when dealing with the skuas. Speaking of the birds of the Keeling Islands, he says: "Graceful Noddies (*Anous stolidus*) and Gannets (*Sula piscatrix*) were in thousands, and I had the satisfaction of watching . . . how their industrious

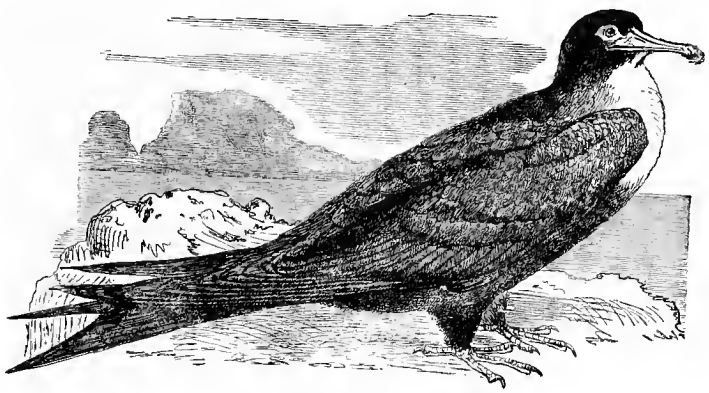


Fig. 344.—Frigate-Bird (*Fregatus*)

habits are taken advantage of by the swift-winged frigate-birds. Hiding in the lee of the cocoa-nut trees, [they] would sally out on the successful fishers returning in the evening, and perpetrate a vigorous assault upon them till they disgorged for their behoof at least a share of their supper, which they caught in mid-air as it fell. . . . Refractory gannets were often seized by the tail by the frigate-birds, and treated to a shake that rarely failed of successful results."

Albatrosses (see vol. i, p. 182) and Stormy Petrels are respectively the largest and smallest of the web-footed birds. They are representatives of two allied families belonging to the Tube-nosed Birds (Tubinares).

The two groups of Diving Birds (Auks, Guillemots, Puffins, Divers, and Grebes) (fig. 345), and Penguins include those birds which are most expert at pursuing fish in the water, and the latter group represents the extreme term in the series of structural modifications for this purpose (see vol. i, p. 187). But this perfect adaptation to an aquatic life is only gained by the complete loss of powers of flight, and great limitation as regards progression on land, for the wings of Penguins are only useful as paddles, and

their legs are set on too far back to be efficient except as propulsive organs in the water. The case is quite parallel with that of Seals among the Mammalia.

Among the numerous enemies of fresh-water fish one of the most attractive is the Kingfisher (*Halcyon*), not infrequent in the southern parts of Britain, and distinguished by its extremely brilliant plumage. The Kingfisher plays a pre-eminently waiting game, remaining motionless on some convenient bough till a

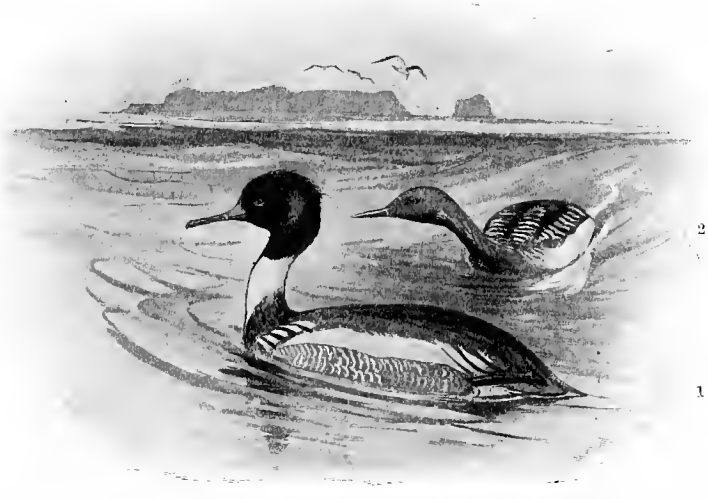


Fig. 345.—1, Red-breasted Merganser (*Mergus serrator*). 2, Black-throated Diver (*Colymbus arcticus*)

suitable quarry makes its appearance in the water below, when with a sudden and exceedingly rapid dart it more often than not has an opportunity of making use of its long and powerful bill. One of the most telling photographs in a recent book on birds by Kearton (*With Nature and a Camera*) shows the Kingfisher perched expectant on its bough, and this attitude is rendered comparatively easy to maintain by the peculiar structure of the foot, in which the toes are joined together in a remarkable manner so as to afford an unusually firm support.

We have seen that Cormorants sometimes, and Kingfishers always, watch for prey from an elevated position. Many birds, however, possess long legs, which enable them to dispense with such a procedure, and also allow them actually to stand in the water on the look-out for prey. Many wading forms are included in this category, such, for example, as the Herons (see vol. i,

p. 178), of which the Common Grey Heron (*Ardea cinerea*) is a good example. The spreading partly-webbed toes afford a firm support to the body even on swampy ground, and the long sharp beak can be brought rapidly into action by the straightening of the long highly-mobile neck. As patient as a kingfisher, the Heron is equally ready for prompt action at the critical moment. The closely-related Stork Family includes birds of much the same build, but with somewhat different habits. The White Stork (*Ciconia alba*) hunts frogs and other small animals in swampy ground, walking around in a dignified manner and not waiting like a heron for prey to pass by. Numbers of the American Wood-Stork (*Tantalus loculator*) co-operate to perform a sort of feeding drill, in which numbers of them tramp about in shallow water, where the bottom is muddy, till it is thoroughly stirred up, the numerous small fish, reptiles, &c., disclosed by the process being promptly bagged.

CHAPTER V

THE FOOD OF ANIMALS—BIRDS WHICH FEED ON INSECTS AND OTHER SMALL CREATURES—SCAVENGERS

Insectivorous birds of various sorts are abundant, among which the wide-mouthed Swallows and Swifts are remarkable for their powers of flight, to which their long wings and forked tails are adaptations. The Night-Jar or Goat-Sucker (*Capri-*

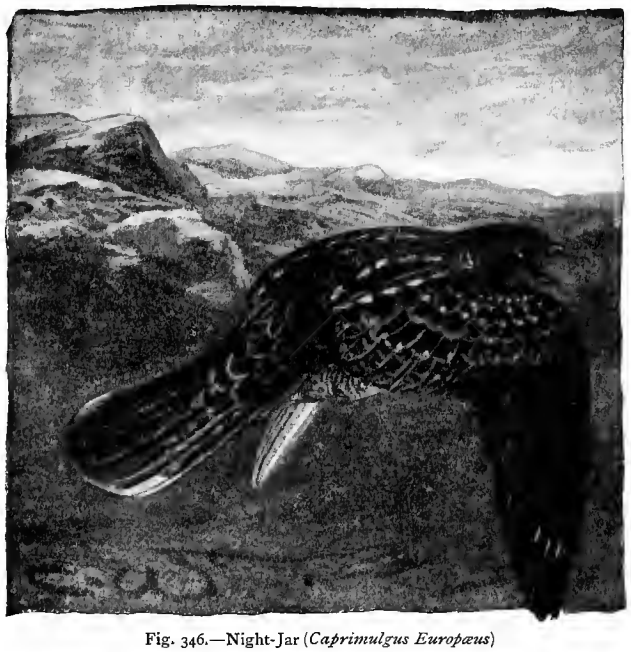


Fig. 346.—Night-Jar (*Caprimulgus Europæus*)

mulgus Europæus (fig. 346) is a soft-plumaged bird, which flies something like an owl, and takes up at dusk and during the night the work which Swallows and Swifts carry on by day. Its widely-gaping mouth is fringed with stiff bristle-like feathers which are no doubt of use in the capture of prey. The following

extracts from Dixon (*Among the Birds in Northern Shires*) will give some idea of the appearance and habits of this interesting form:—"Like most birds possessing some peculiarity in note or appearance easily remarked by the multitude, the present species has many aliases, some of which at any rate are as undeserved as they are disastrous. Thus, that of 'Night-Hawk' brings the bird into evil repute with gamekeepers, and it is shot down in many localities under the firm belief that it preys upon young pheasants and partridges. That of 'Goat-Sucker' is even more widely prevailing, not only in our own country, but it has an equivalent in almost every European language, in some cases dating from a very remote antiquity. Needless to say that this appellation has proved even more fatal, and has caused the poor bird needless persecution in many other countries than ours, owing to the absurd superstition it describes and fosters of the Night-Jar's utterly fictitious habit of sucking the teats of cows and goats. Lastly, it has been the long-suffering possessor of the names of 'Fern-Owl' or 'Churn-Owl', one relating to its haunts, the other to its singular note, and both suggestive of birds that have been sorely persecuted by man, in most cases for purely imaginary offences. Anything flying under the name of 'Owl', whether with 'fern', or 'wood', or 'barn', or 'horned' attached, is considered harmful, and fair food for powder and shot, so that the poor Night-Jar has suffered with the rest. To his habits and appearance most, if not all, his misfortunes are due. He flies about at dusk and during the nighttime, and has a way of flitting round the cattle in the meadows close to the heath in quest of moths and cockchafers; his plumage is soft and pencilled and owl-like, whilst his enormous mouth, to the ignorant countryman, seems capable of swallowing anything. And yet there is no more harmless bird in the British Islands than the Night-Jar. It preys upon no single creature that man might covet (if perhaps we except the entomologist, who does not like to see rare moths and beetles disappear like magic in the evening gloom), but, on the other hand, rids the fields and groves of countless numbers of injurious insect pests. . . . The bird, like the bat and the owl, sleeps during the daytime, either crouched flat upon the ground or seated lengthwise on some broad flat branch of a tree where dense foliage gives the shade and gloom it seeks, and where its beautifully-mottled and vermiculated

plumage harmonizes most closely with surrounding tints." The Whip-Poor-Will of North America (*Caprimulgus Virginianus*) is a closely-allied species.

Quite another sort of arrangement is presented by Woodpeckers (fig. 347), in which the foot is admirably adapted for climbing, having two long toes directed forwards and two others backwards, all being provided with sharp claws that can take advantage of the smallest irregularities on walls, the bark of trees, and similar surfaces. The stiff tail is also of assistance in climbing. The powerful pointed and rather long beak is suited for introduction into crevices, and the mobile tongue, covered at its tip with backwardly-directed spines and rendered sticky by the secretion of large glands, is an excellent insect-catching organ. The arrangements found in some insectivorous Mammals are here once more recalled. It should further be added that the "hyoid bone", by which the tongue is supported and to which the muscles moving it are attached, is unusually well developed, and possesses slender prolongations which curl round over the top of the head underneath the skin.



Fig. 347.—Greater Spotted Woodpecker (*Dendrocopus major*)

The Common Cuckoo (*Cuculus canorus*), which is related to the Woodpeckers, may be mentioned in passing as an insectivorous bird of great voracity, and is especially interesting as having discovered a hunting-field in which little if any competition is encountered. That is to say, it feeds largely upon hairy caterpillars, which other birds find extremely distasteful and never touch if they can help it.

Many of the sharp-beaked Perching Birds feed largely upon insects in their various stages, as well as upon other small creatures, but space forbids mention of more than a few examples.

Among the most interesting are the Creepers, of which the Common Creeper (*Certhia familiaris*) (fig. 348) is abundant in



Fig. 348.—Common Creeper (*Certhia familiaris*)

Britain, though it often escapes observation on account of its dull coloration harmonizing with the tree-trunks and walls upon which it hunts insects, spiders, and other small animals. The

toes of this bird are provided with long curved claws well suited for clinging to rough surfaces, and climbing is helped by the stiff-pointed tail-quills. The long slender curved beak is sharply pointed and well adapted for probing in crannies and crevices.



Fig. 349.—Blue Roller (*Coracias garrulus*)

Although a long probing beak is common among insect-eating birds, this organ is short and conical in many species living on the same sort of food. This is the case with the attractive little Tits, which do a vast amount of execution among the branches of trees, though of course they can only reach insects, &c., which are on or near the surface, leaving those which lie deeper to be tackled by woodpeckers and creepers.

The Blue-Roller (*Coracias garrulus*) (fig. 349), widely distri-

buted through Europe, Asia, and North Africa, is found in districts where tall trees are mixed with underwood, and its powerful slightly-hooked beak suggests that its diet includes animals higher in the scale than insects. Such a conclusion is borne out by the facts, for it hunts upon the ground for lizards and frogs, as well as worms and insects, besides which it catches these last on the wing.

The common names of some families of perching birds have reference to their insectivorous habits, as, *e.g.*, in the case of the

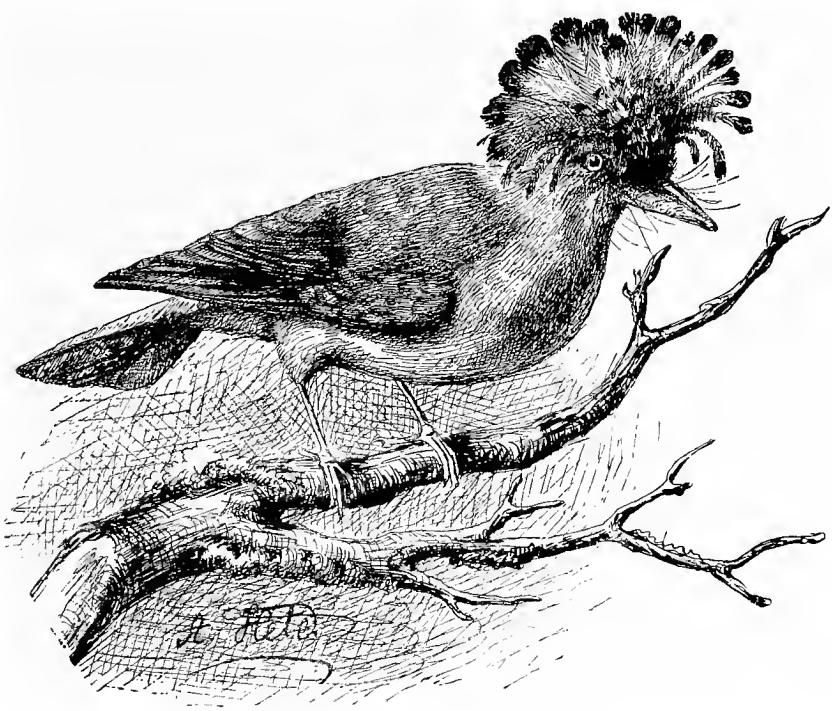


Fig. 350.—Crowned Tyrant (*Muscivora regia*)

Old World Flycatchers (*Muscicapidæ*), represented in this country by three species, of which the commonest is the Spotted Flycatcher (*Muscicapa grisola*). These birds catch insects on the wing, frequently settling on the branches of trees, from which they dart out at their prey.

The American or Tyrant Flycatchers (*Tyrannidæ*) are distinguished by similar habits to those of the last-named family. The Crowned Tyrants (*Muscivora*) of Mexico and South America (fig. 350) are possessed of beaks flattened from above downwards.

Some of the perching birds make a living by feeding on the insects, ticks and the like, which infest many of the larger Mammals. Such are the Ox-Peckers of the African continent, a well-known Natal species being the African Ox-Pecker (*Buphaga Africana*) (fig. 351). These birds are closely related to the starlings, and their feet are provided with strong curved claws,

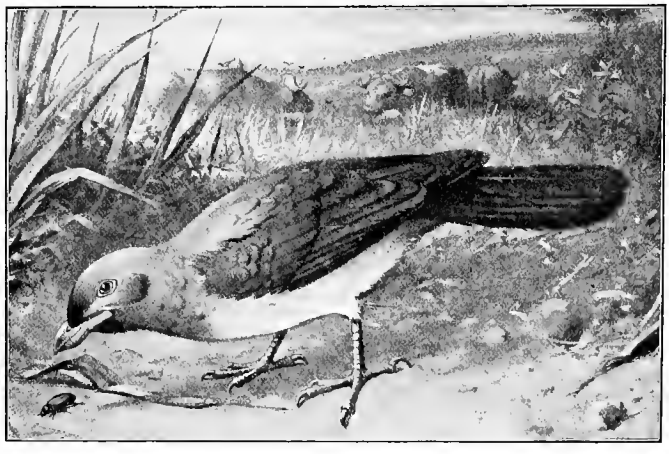


Fig. 351.—African Ox-Pecker (*Buphaga Africana*)

by means of which, and with the help of their tails, they are able to climb about on the bodies of oxen, buffaloes, and other large animals. Their strong straight beaks deal most effectively with the creatures preyed upon, and the lower mandible is used as a lever for extracting bot-fly larvæ from the skin. J. G. Millais (in *A Breath from the Veldt*) gives a vivid account of the habits of this bird, from which the following is quoted:—"It is most interesting to notice the way in which a party of these birds will move about on the body of a horse or ox, searching every part of his skin as they run or hop over it in the most lively fashion. . . . It is quite immaterial to them how or in what direction they move. They are continually on the hop, and seem almost capable of hanging on by the proverbial eyelids. . . . Your oxen are no sooner outspanned than a party of these interesting birds spy them out, and come and sit on the neighbouring trees till the beasts have been watered and have settled down to steady grazing. Then they rise in the air, and after flying in a circle once or twice over some likely-looking ox, they descend and settle all in a row along its backbone, where they sit stolidly for a

moment or two, to see if there is any fear of disturbance during their coming meal. The whole party then set to work and scour the entire body of the animal, a proceeding which the latter seems thoroughly to appreciate, for it is no uncommon sight to see an ox lying stretched out on the ground, exposing every part of his body to their ministrations. When they have got all they can out of one beast they pass on to another, and repeat the process till their appetite is satisfied."

While the Ox-Pecker obtains a large part of its food from the bodies of domesticated animals, another well-known and widely-distributed bird, the White-eared Honey-Guide (*Indicator Sparmanni*) (fig. 352), a near relative of the woodpeckers, makes use of man himself, but in a different way. Knowing that human beings have a weakness for honey the ingenious bird acts as a guide to bees' nests, taking the grubs and young bees as his share of the spoil. We cannot do better than make another quotation from Millais:—"The marvellous reasoning-power of the latter (*i.e.* the Honey-Guide) seems to demand some better word than instinct. . . . Mentally marking every nest of bees in a certain locality, he hangs around till he meets with a friendly biped, to whom he makes known his presence and his desire by a pleasant chuckling note. This he keeps up incessantly as long as the man is in view. Then, after a short undulating flight of about 100 yards, he generally alights on a dead bough, so as to make himself as conspicuous as possible, and loudly continues his chuckling. If not attended to, he returns again and again with increasing audacity, as I have previously described; but if followed, he waits till the man

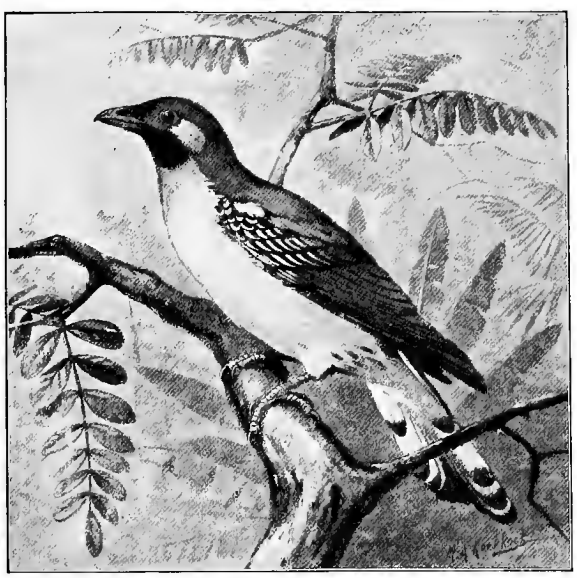


Fig. 352.—White-eared Honey-Guide (*Indicator Sparmanni*)

comes within 50 yards, and then continues his flights, which vary from 100 to 200 yards, till the nearest nest is discovered. There is pretty sure to be a dead bough about, or the bees would not be there; and on this he settles with his eyes towards the bees' nest. . . . The nest is generally plastered up with mud and not very difficult to extract; and while you are engaged in this operation the Honey-Guide sits quietly on the tree, trusting to your honour to give him a share of the plunder, which I need hardly say is always done by the natives."

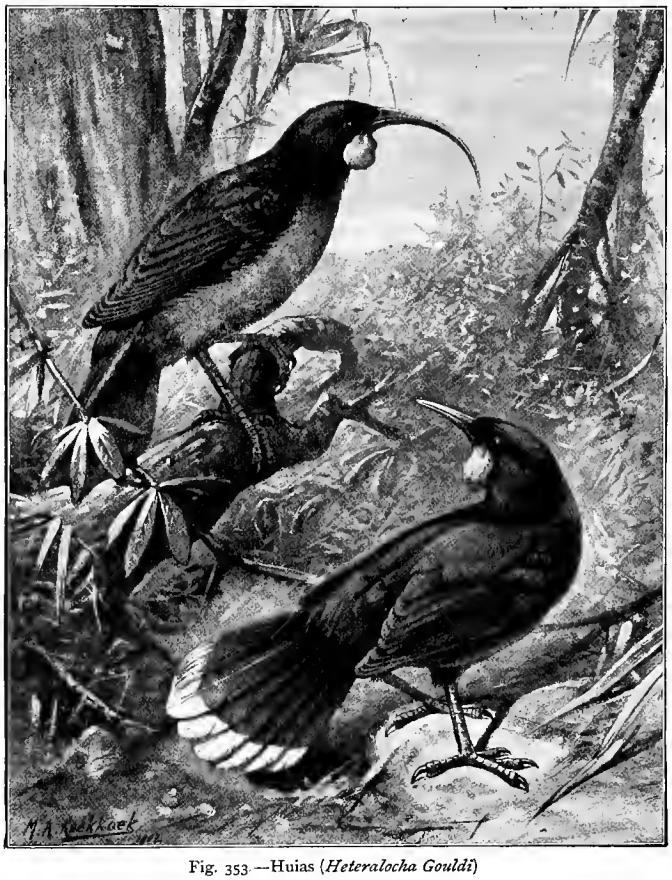


Fig. 353.—Huias (*Heteralocha Gouldi*)

A very curious specialization of the beak in reference to insect food is exhibited by the Huia (*Heteralocha Gouldi*) (fig. 353) of New Zealand, a member of the crow family. This bird feeds upon large beetle-grubs inhabiting decayed wood, and while the beak of the male is strong and pointed, that of the female is long, curved, and flexible. The arrangement is a clear case of division of labour, for the male is able to chip away the decayed wood so as to expose many of the grubs, while the female can insert her slender beak into holes which her partner is unable to reach. Between the two of them it fares hard with the beetle-grubs.

Shrikes, or Butcher-Birds, as regards beak and feet, closely

resemble birds of prey. They feed on insects and small vertebrates, and impale such prey as are not immediately required upon thorns, often forming in this way a very respectable "larder" (fig. 354).

A considerable number of well-known birds feed upon worms, snails, and other small animals which are found in the mud of



Fig. 354.—Great Butcher-Bird (*Lanius excubitor*)

ponds and streams, or in damp marshy places. Everyone has seen a Duck in the water, with its tail turned up, engaged in this sort of work, and in this animal the broad bill (fig. 355) acts as a strainer, and is exquisitely sensitive, enabling the creature to effectively sift the wheat from the chaff, if such a metaphor be permissible. The long neck of the Swan enables it to investigate somewhat deeper water with the same practical aim. Ducks and Swans, however, are not purely carnivorous.

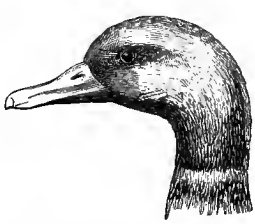


Fig. 355.—Head of Duck (*Anas boschas*)

A number of birds are fond of haunting the banks of streams and ponds with a view of catching insects and other small animals. Among the most attractive and familiar of these are the Wagtails (fig. 356), of which there are five British species, the most familiar being the Pied or Water Wagtail (*Motacilla lugubris*). The slender pointed beak is obviously suited to an insect diet. W. Warde Fowler (in *Summer Studies of Birds and Books*) speaks thus of the little group of birds now under considera-

tion:—"It is impossible ever to weary of Wagtails. We are never altogether without them, yet whenever they present themselves to us we are constrained to give them our attention. . . . They all

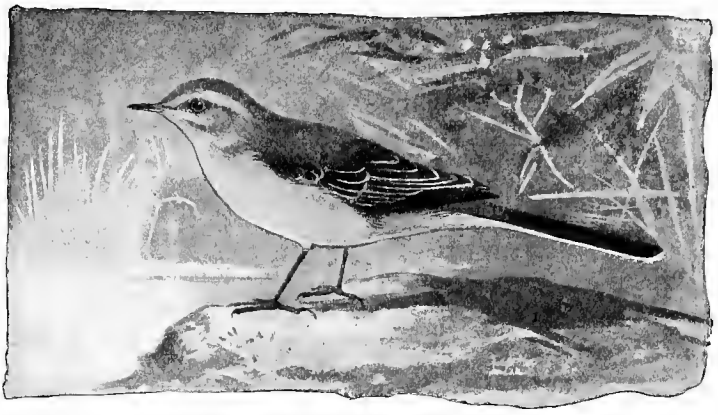


Fig. 356.—Yellow Wagtail (*Motacilla flava*)

walk, or rather run, instead of hopping, their delicate little legs being often in such swift motion as hardly to be seen as they go; and all feed chiefly on insects—largely, I think, on minute beetles



Fig. 357.—Black-tailed Godwit (*Limosa Belgica*)

—and love our British streams and meadows for the never-failing abundance of food they find there."

The sea-shore is a favourite resort of many birds besides the

fish-eating forms, some species making it their usual hunting-ground, while others make occasional visits. Among the former may be mentioned two interesting birds of the Plover Family—the Turnstone and the Oyster-Catcher. Everyone who has hunted for little beasts along the shore, and most of us as children have

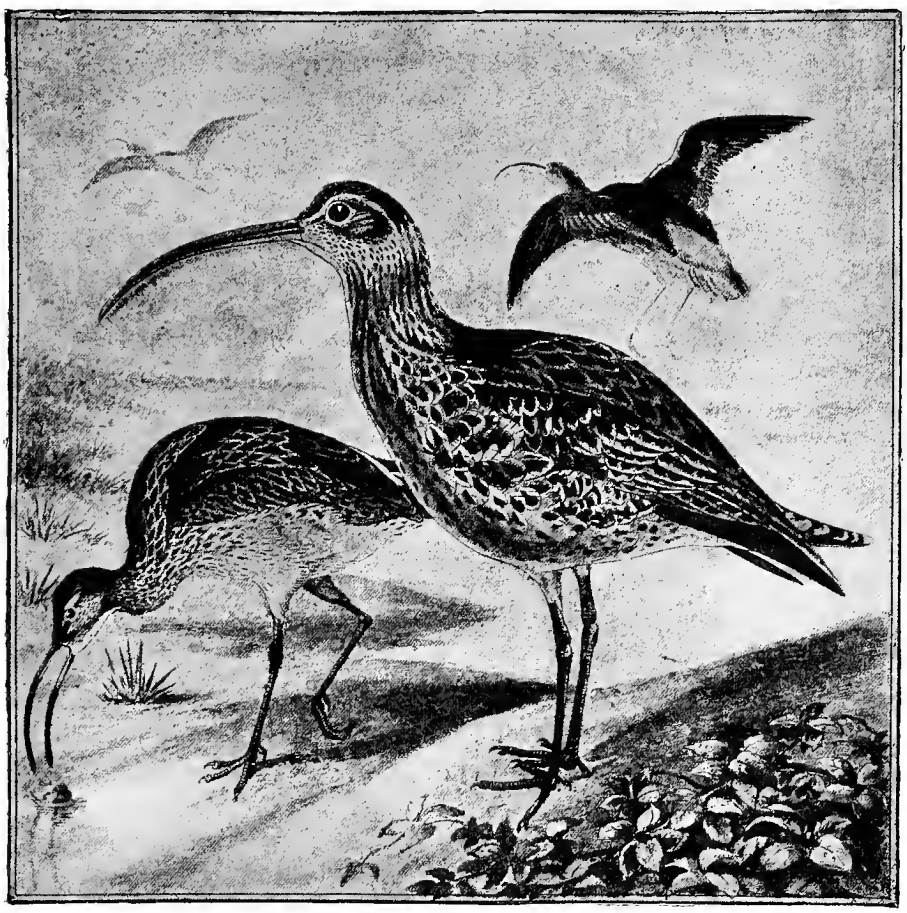


Fig. 358.—Curlew (*Numenius arquatus*)

done so, knows that sand-hoppers, small crabs, and a host of other diminutive creatures harbour under stones. The Common Turnstone (*Strepsilas interpres*) is well aware of the fact, and uses his strong beak for turning over stones, a method of pot-hunting which brings its own reward. The black-and-white Oyster-Catcher (*Hæmatopus ostralegus*) possesses in his powerful laterally-compressed beak a means of opening various bivalve

molluscs, of detaching the tenacious limpet caught unawares, and of securing sundry creatures which burrow in the sand and thoughtlessly come too near the surface.

Godwits (fig. 357) and Curlews (fig. 358) are plover-like birds with long legs which enable them to wade to some extent when searching for food. The long slender beak (curved in the Curlews) is well suited for probing in mud, moist earth, or sand, with the object of securing such small animals as live therein. During the summer these birds frequent moors and marshy uplands, and vary their animal diet with berries and the like, but in winter they haunt the sea-shore, and are then more strictly of carnivorous habit.

The last point suggests the habits of another member of the Plover Family, *e.g.* the Long-beaked Woodcock (*Scolopax rusticola*) (fig. 359), which searches for worms along the banks of streams and in marshy ground. The sensitive beak bores deep into the mud, and is kept motionless until, perchance, some contiguous worm inadvertently wriggles, and next moment is as often as not captured by a sudden thrust on the part of the aggressor. A similar procedure is adopted by the smallest living flightless bird, the Kiwi (*Apteryx*) (see vol. i, p. 190) of New Zealand, and in this case the nostrils are placed close to the tip of the long beak, a very unusual position. As might be expected



Fig. 359.—Woodcock (*Scolopax rusticola*)

from this arrangement the Kiwis largely rely on the sense of smell when hunting for worms, at which time they make a sniffing sound. Unlike the woodcocks they appear to detect their prey before driving in the beak, as this procedure is commonly successful straight away.

There are among Birds, as among Mammals, forms which are specially adapted to feed on carrion. The best known of such scavenging birds are Vultures and Adjutants. The former are closely related to the Hawks, but present a peculiar appearance owing to the bareness of their heads and necks, a feature which has obvious relation to the nature of the food. Adjutants, which are to be looked upon as large and specialized Storks, present the same peculiarity, which is no doubt an adaptation to the same end.

CHAPTER VI

THE FOOD OF ANIMALS—CARNIVOROUS AND INSECTIVOROUS REPTILES

CROCODILES

Reptiles exhibit many forms of adaptation to an animal diet. We may fitly begin with the CROCODILES and their allies, which are at the same time the most highly organized and the most formidable members of the class (see vol. i, p. 21).

The well-known Nile Crocodile (*Crocodilus Niloticus*) will serve as an average illustration. The seizing organ is here constituted by the powerful jaws, with their numerous strong, pointed, and interlocking teeth, which, once having got a firm grip, rarely leave go. Even a large Mammal, when caught, struggles in vain, but is steadily drawn under water and drowned, after which it is devoured by a series of tearing snaps. The Crocodile itself might easily get choked during this drowning process were there not some special provision to prevent it. This preventive arrangement consists in the extreme backward position of the internal nostrils, and the upward projection of the top of the windpipe into the hinder part of the nasal passages. Thus the mouth can be kept more or less open under water without any risk of suffocation. We are reminded here of a similar contrivance among the Cetacea, the existence of which is due to a similar reason. Although Crocodiles are capable of fairly rapid progression on land, they are specially adapted to swift movement in the water, the laterally-flattened tail acting as the organ of propulsion. This powerful structure can also be used as a flail, by the sudden use of which unwary animals standing close to the water's edge, as for the purpose of drinking, are swept within the range of the jaws. Much, if not most of the success of the Crocodile as a hunter, is due to his craftiness. Floating like a log in the water he is able to approach his prey

without arousing suspicion till within striking distance. The following quotation from Sir Samuel Baker (in *Wild Beasts and their Ways*) furnishes a good example:—"I have watched upon many occasions the stealthy advance of a crocodile to capture small birds, when in flights of many thousands they have settled upon the yielding branches of dwarf willows overhanging the Atbara river. The elastic boughs bent down beneath the weight of the innumerable flock, and the crocodile's head appeared above the surface at a distance, sank below, and quickly reappeared (the eyes and crown alone above the water) within 10 yards of the unsuspecting birds, all of which were busily engaged in twittering excitement, quarrelling for places, and occasionally dipping their beaks in the water when the bending twigs permitted them to drink. In a few moments after the disappearance of the wary eyes a tremendous splash was accompanied with a pair of open jaws, which swept the occupants of the lower branches into the greedy throat. This artful attack was frequently repeated, and generally with success."

As regards the internal arrangements of the Crocodile it may be noted that the gullet is very dilatable, allowing prey of considerable size to be swallowed, and part of the stomach is a sort of gizzard, within which stones and gravel are always to be found. Here, as in the case of birds, is an arrangement which compensates for the absence of chewing organs.

As might be expected, fish is an important item in the diet of members of the group under consideration, but the slender-snouted crocodiles known as Garials appear to be specially adapted to this kind of food. The Gangetic Garial (*Gavialis Gangetica*), for example, which inhabits some of the Indian rivers, possesses a very long beak-like snout armed with very numerous teeth, and well suited for dealing with this kind of prey. A comparison naturally suggests itself with some of the fishing-birds, and still more with the curious Cetacean known as the Gangetic Dolphin (see p. 28).

TORTOISES AND TURTLES

Some of the members of the TORTOISE and TURTLE ORDER are of carnivorous habit, but there are no very special adaptations to an animal diet. It is among the fresh-water forms that

those most addicted to animal food are to be found, and decidedly the most aggressive of these are the American Snapper-Tortoises, of which an example is the Alligator-Terrapin (*Chelydra serpentina*), which ranges from Canada to Ecuador on the eastern side of the mountain axis of the New World. As the common name suggests, there is a powerful flattened tail, which serves as an efficient swim-

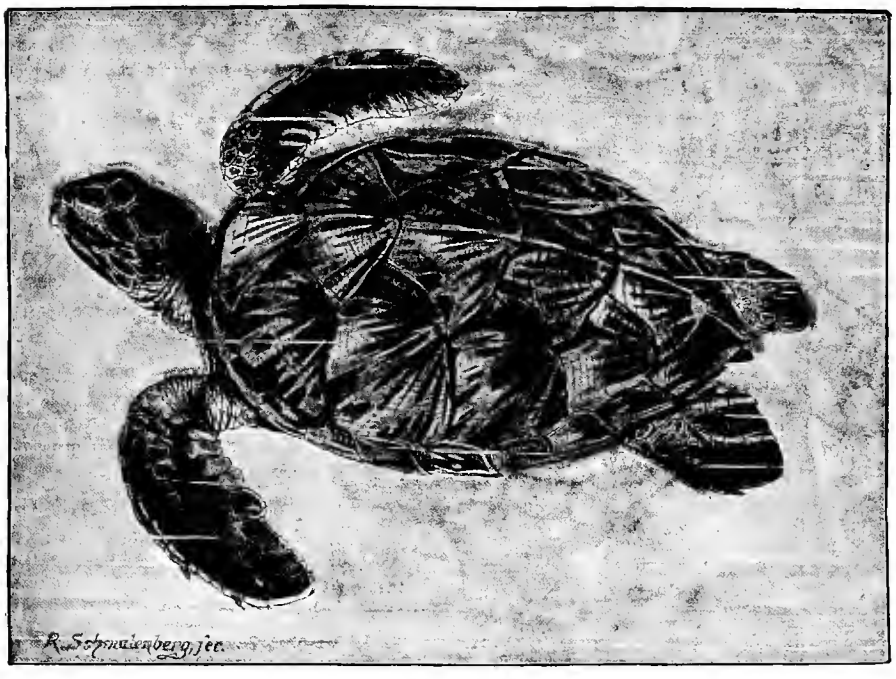


Fig. 360.—Hawk-bill Turtle (*Chelone imbricata*)

ming organ, enabling the animal to overtake the frogs and fish upon which it chiefly feeds. Its powerful jaws are covered with a strong horny sheath, and they are brought together with a sudden and effective snap at the psychological moment. The Hawk-bill Turtle (*Chelone imbricata*), from which the "tortoise-shell" of commerce is obtained, is also purely carnivorous in habit, and its hooked beak is correlated with the nature of its food (fig. 360).

In most Chelonians the rigidity of the trunk is made up for by the extreme mobility of the neck, and in some members of the order this would appear to be of importance in the capture of prey. The Snake-necked Tortoises (*Hydromedusa*) of South America, for example, possess exceedingly long necks, which can either be folded back within the shell or thrust out with great swiftness.

LIZARDS

The large and widely-distributed order of LIZARDS is in the main an assemblage of carnivorous species, most of which are suited to a life on land. All sorts of animals serve as food, from small backboned animals down to insects, snails, and worms. Our native species are typical representatives of an Old World family rich in species, of which the chief food is insects. Extreme agility and the possession of numerous small, pointed teeth are obvious attributes, both of which appear to be related to the nature of the food.

The Monitors constitute a group of large Lizards ranging from Africa through the south of Asia into the Australian region, and feeding upon various backboned animals, such as frogs, reptiles, birds, and small mammals. As might be expected from the nature of the food, the teeth are large and pointed. The different species live in very different surroundings, and exhibit specializations of corresponding kind. The Desert Monitor (*Varanus griseus*) inhabits the deserts of North-west Africa and South-west Asia, and is rendered inconspicuous in its natural surroundings by its dull coloration. The powerful cylindrical tail is used as a weapon. The Papuan Monitor (*V. prasinus*) is believed to live among trees, and its tail is shaped like that of the last-named species. Most of these Lizards, however, have tails which are strongly flattened laterally, a feature usually associated with the power of swimming. An example is the Nile Monitor (*V. Niloticus*) (see vol. i, p. 224), which frequents most of the African streams, and preys largely upon the eggs of crocodiles. And as a last example we may take the Water Monitor (*V. salvator*), which is the largest of the series, attaining a length of pretty nearly 7 feet. Its range extends through South Asia to Australia, and it is mostly found in marshy ground in the neighbourhood of water, both salt and fresh. Not only can the animal swim, but also climb among trees, devouring smaller lizards and also birds, as well as the eggs of the latter. It has a curious method of egg-eating, for an egg is first seized in the jaws, the head is turned up, and the egg-shell broken with the teeth in such a way that the contents can be readily swallowed.

Among the most interesting climbing lizards are the small insect-eating forms known as Geckoes and Chameleons. Geckoes

(see vol. i, p. 221) are exceedingly active creatures, in which the toes are provided with climbing pads on the under-surface, the structure of which will be described elsewhere. Almost universally distributed throughout the hotter parts of both New and Old Worlds, including Australia, the Geckoes have attracted a good deal of attention from the fact that they are often found in houses, hunting down insects on the walls and even on the ceilings, along which they can climb in an inverted position.

Even better known than the Geckoes, on account of their quaint form and power of changing their colour to harmonize



Fig. 361.—Chameleon seizing its Prey

with local surroundings, are the Chameleons (fig. 361), which are distributed throughout Africa, and are also found in western and southern Asia. All the Lizards, so far considered, are distinguished by their extreme activity, but the Chameleon is a sluggish creature as regards locomotion, and is usually found holding firmly on to a branch by means of a prehensile tail and very curious feet, in which the digits are bound together in two groups, so as to give considerable grasping power. No better description has ever been written of the way in which a chameleon catches its prey than that by Professor Lloyd Morgan (in *Animal Sketches*), from which the

following is quoted:—". . . Our chameleon is a beast of prey. Insects are its food. See, a fly has settled on that bough, within six inches of our largest lion. But what chance has the slow and sedate chameleon, slowest and sleepiest of lizard-folk, what chance has he of catching an active and wary fly? His cone-shaped swivel eyes are looking about aimlessly, each seeming bent on some business of its own. Now one glances lazily up, while the other peers furtively down. Now one is staring attentively backwards at its owner's tail, while the other is ranging round the neighbourhood of that wide-awake little fly, who is rubbing her front legs together, or drawing her hind-legs over her wings, in utter carelessness of the presence of so inanimate an enemy. But make not too sure. One eye has ceased its aimless wandering, and becomes earnestly interested in that fly. The chameleon takes one solemn step forward. You are all right for the present, Mrs. Fly; but let me advise you to be careful and circumspect. That one eye is fixed upon you with an unchanging, steady gaze, and the other seems somehow to have lost its interest in its owner's tail, and is beginning to find a new interest in your immediate neighbourhood. If once that other eye becomes fixed upon you, take my word for it, you're a doomed fly. Ah! I thought so. The other eye has come to rest, and holds you in its steady gaze. The chameleon leans forward a little, his mouth slowly opens, twitches once or twice, and quick as thought, with unerring aim, a long worm-like tongue is darted forth and returns to the mouth like a piece of stretched india-rubber. Where is poor Mrs. Fly? She seems to have disappeared. And Mr. Chameleon is leisurely munching at something which seems to give him some sort of sedate satisfaction." Here again we have the device of a long sticky tongue as an insect-trap that was noted in some ant-eating mammals and in woodpeckers. In this case the organ in question has a curious swollen end.

We have seen that Lizards of various kinds hunt their prey on the ground, among trees, and also in the water; but this does not exhaust the possibilities of the group, for there are a number of burrowing species. Prominent among these are the Skinks, stumpy-looking creatures, in which the spindle-shaped body with smooth surface is well suited to the habit, to which the short powerful limbs and transparent lower eyelid, acting as a protective window, are further adaptations. Types of the group are the

Common Skink (*Scincus officinalis*) (fig. 362) of the Sahara and Red Sea regions, and the remarkable Stump-tailed Lizard (*Trachysaurus rugosus*) (see vol. i, p. 226) of Australia. Specialization of a far more profound nature to suit a burrowing habit is displayed by the worm-like Amphisbænas, most of which are natives of the hotter parts of Africa and America, and which owe their name to the fact that they can move forwards or backwards with equal ease. The Handed Amphisbæna (*Chirotes caniculatus*), native to California and Mexico, is one of the least modified members of the group, for it still possesses small fore-limbs, though the hind ones are entirely absent; but in most other cases, as, for example, in the Spotted Amphisbæna (*A. fuliginosa*) of tropical America and the West Indies, neither pair of extremities is present. The food consists of insects and worms.

There is another group of Lizards in which the body is long and cylindrical, so as to give a snake-like appearance. These Snake-like Lizards (see vol. i, p. 225) are adapted for progression through thickly-growing vegetation, like the animals they resemble, and according to their size they prey upon either small vertebrates or various lower forms of life. Natives of America, and to a less extent of Europe and south Asia, some of those from the first-named continent, possess small limbs. Many species, however, are quite devoid of extremities, as illustrated by the common Blind-Worm (*Anguis fragilis*), which frequents woods, downs, and heaths in Britain, feeding upon snails, slugs, worms, and insects.

SNAKES

The members of the vast order of Snakes, which reaches its maximum development in tropical regions, are specialized on somewhat the same lines as the snake-like lizards. Like these they are undoubtedly descended from reptiles possessing well-developed limbs, and in some of the large snakes, such as pythons, insignificant vestiges of the hind-limbs are still present, but are not concerned in locomotion.

Snakes exhibit a great diversity of habitat. The large majority pursue their prey upon the ground, others live among trees, some few burrow in the ground, while others again are adapted

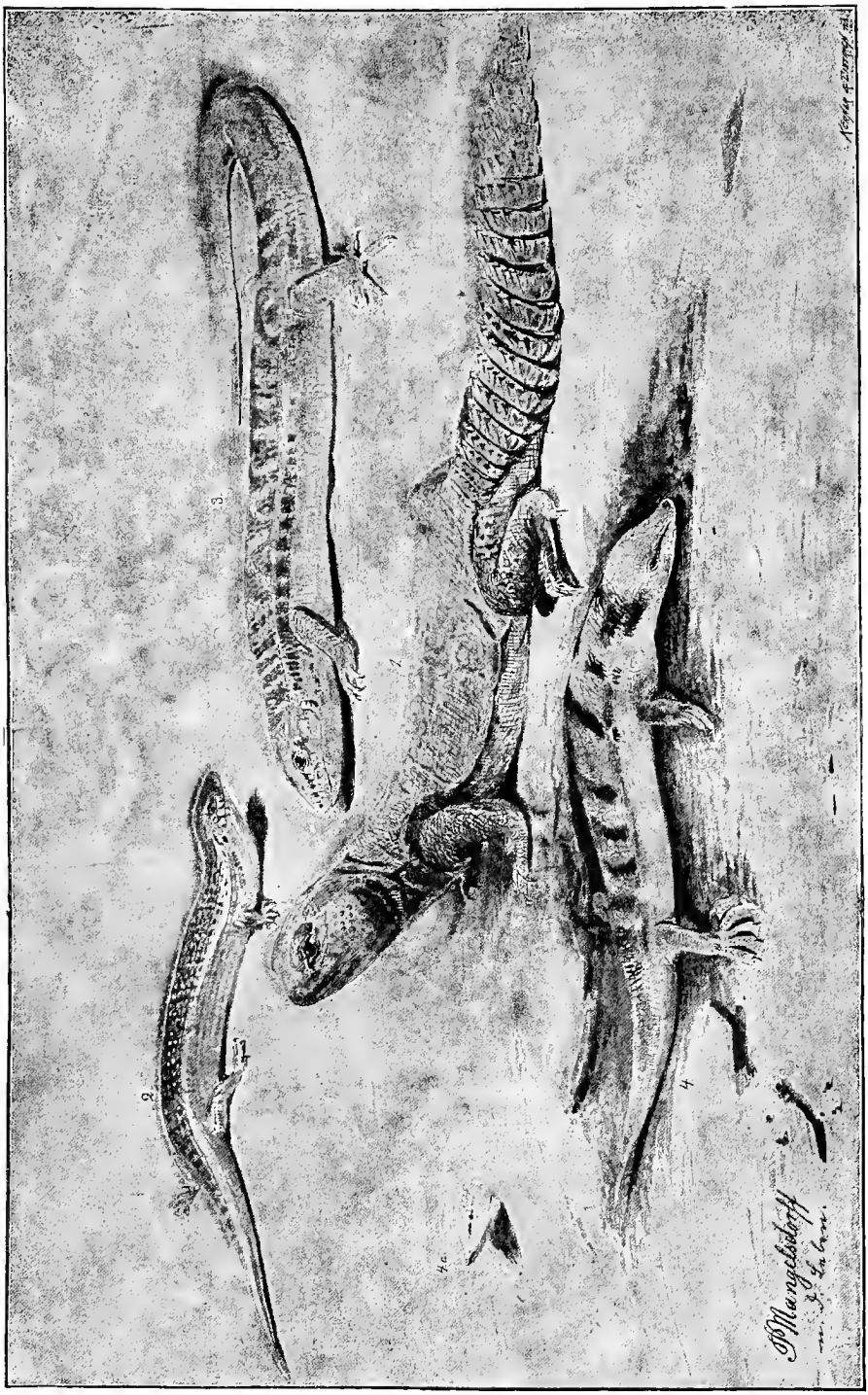


Fig. 362.—Tunisian Lizards

1, Thorny-tailed Lizard (*Uromastix acanthinurus*). 2, Bronze Lizard (*Chalcides ocellatus*). 3, Cylinder Lizard (*Euneces Schneideri*). 4, Common Skink (*Scincus officinalis*). 4*a*, Head of a skink projecting from the sand.

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for life in fresh water or even in the sea. The prey in most cases consists of living animals, often of relatively large size, and it is clear that a comparatively narrow animal, devoid of any chewing arrangement, must be modified in structure so as to enable it to deal with such prey, which after capture has to be swallowed whole. The mouth, of course, must be capable of great dilatation, and this is made possible by the presence of a double hinge-joint where the lower jaw is attached, and by the fact that the two halves of the lower jaw are connected in front by an elastic band instead of being firmly united together as is the rule in backboned animals. Escape of the prey when this is swallowed alive, as is usually the case, is prevented by the sharp, backwardly-curved teeth. There must also be some way of preventing the snake from choking during the slow process of swallowing, and this is found in the peculiar nature of the top of the windpipe, which is drawn out into a cone that protrudes from the corner of the mouth while the prey is passing slowly down the gullet. Not only is the mouth capable of great expansion, but also the gullet and stomach, as well as the part of the body in which they are contained, an important point to notice here being the complete absence of a breast-bone and limb-girdles, which, if present, would prove a serious hindrance to the excessive dilatation which is absolutely necessary. Although an average snake affects meals of a bulky sort, which are digested with comparative ease, long intervals elapse between them. A constant supply of water for drinking is, however, indispensable.

Snakes have various ways of dealing with their prey, and it will be convenient to take harmless forms first, afterwards considering the nature and mode of action of the poison-apparatus in the venomous species. A convenient point of departure is afforded by the common Grass Snake (*Tropidonotus natrix*) (see vol. i, p. 233) of Britain, which feeds on frogs, small mammals, birds, and even fishes, for it is an expert swimmer. These are secured by the numerous pointed teeth, and swallowed alive. The unfortunate frog, which has so many enemies, from man downwards, is the favourite prey of this snake, which, as so often happens with these reptiles, seems to exert a kind of hypnotic influence upon it, for, instead of trying to escape, it stands still, uttering cries of fear. Next moment it is seized and gradually swallowed, protesting meanwhile in a way which is far from pleasant to witness.

POISONOUS ASIATIC SNAKES

Poisonous serpents, which for the most part inhabit tropical or sub-tropical regions, are provided with very effective offensive and defensive weapons, in the form of poison-glands, of which the venom is conveyed along certain specialized teeth, known as the "fangs", into the wounds made by these organs. It is a case of biting, and not stinging as often supposed. Often, but by no means always, the presence of the poison-glands causes the head to be broadened out behind. Some such forms evade observation by being coloured in such a way as to harmonize with the colour-scheme of their surroundings. Others exhibit striking tints and patterns which make them very conspicuous. This Warning Coloration advertises their noxious properties to animals which might otherwise destroy them. The conspicuousness may be increased by the assumption of Warning Attitudes, or the emission of Warning Sounds.



POISONOUS ASIATIC SNAKES

1. Banded Adder or Raj-samp (Bungarus fasciatus).
2. Tree Viper (Trimeresurus gramineus).
3. Russell's Viper (Vipera Russelli).
4. Giant Cobra (Naja bungarus).
5. Desert Saw-Viper (Echis carinata).
6. Cobra-de-capello or Kala-nag (Naja tripudians).
7. Long-glanded Serpent (Adeniophis intestinalis).

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The largest known snakes, Pythons and Boas (see vol. i, p. 231), as well as many smaller kinds, adopt a much more merciful procedure than the Grass Snake, for they kill their prey by crushing it in their coils before beginning to swallow it, the latter proceeding being greatly facilitated by the secretion of large quantities of saliva. The largest of all such species is the gigantic Anaconda (*Euneces murinus*), inhabiting the tropical forest regions of South America, where it haunts the rivers and their neighbourhood, often hanging head downwards from a tree on the look-out for prey. Many such reptiles are thoroughly arboreal in habit, as for instance the Tree-Boas of tropical regions, though their climbing powers do not preclude expertness in swimming.

A certain number of snakes are adapted for pursuing such prey as can be found underground, more especially earth-worms. The most important are the Shield-tailed Snakes (*Uropeltidæ*) of India and Ceylon, and the widely-distributed Blind-Snakes (*Typhlopidæ*), found for the most part in tropical regions. They are never of large size, and their smooth scales present but little resistance to passage through the earth, while, as so often happens in creatures which lead an underground life, the eyes are much reduced, and in this case are protected by special shields. The nature of the food does not demand those expansive powers which are so characteristic of average snakes, and the mouth is consequently small and incapable of being stretched to any extent.

Poisonous Snakes. We now pass to the consideration of poisonous forms, which are distinguished by the grooved or tubular nature of some of the teeth attached to the margin of the upper jaw, the object of this being to conduct poison into any wound which may be inflicted. Such modified teeth may be situated either at the front or back, and though their presence may be taken to indicate a greater or less degree of poisonous properties, it by no means follows that all such forms are dangerous to man. The slender Whip-Snakes (*Dryiophidæ*) of India and the Malay region are among the forms where the poison-fangs are formed by modification of the hinder teeth. They are arboreal in habit, climbing among trees with great rapidity, and preying upon small vertebrates, such as birds and lizards. Well-known examples of venomous serpents, in which the poison-fangs are at the front end of the upper jaw, are the brilliantly-coloured Coral-Snake (*Elaps*) of South Africa and the hotter parts of America,

the Cobra de Capello (*Naia tripudians*) and Giant Cobra (*N. bungarus*) of South Asia, the African Asp (*N. haie*), and the Death-Adders of the Australian region. Here also are included the poisonous Sea-Snakes (*Hydrophidæ*) of the Indian and Pacific Oceans.

The poison arrangements, however, are by far the most specialized in the great group of Vipers (*Viperidæ*), represented in this country by the Adder (*Pelias berus*), and which includes such notorious forms as the Puff Adder (*Vipera arietans*) of Africa and the Rattlesnake (*Crotalus durissus*) (see vol. i, p. 235) of North America. It is serpents of this kind in which the flattened head, broad at the back, presents the oft-cited resemblance to the ace of spades. The breadth is mainly due to the presence of very large poison-glands, one behind each eye (fig. 363). These are modified salivary glands, and therefore furnish an instance of the principle of "change of function" which has elsewhere been noted. Each of them is covered by a layer of muscle, which by its contraction forces out poison into the fang-canals at the moment when the snake opens its mouth to "strike" its prey. It is, however, in the structure of the upper jaw that the viperine snakes are most remarkable. The external bones (*maxillæ*) of this region are attached by a hinge-joint to the skull, so that they can be moved forwards or backwards. They are extremely short, and instead of carrying a number of teeth, as in the front-fanged and hind-fanged species, each of them bears but a single tooth in the form of a long sharp poison-fang, traversed by a canal which is open both above and below. Through the upper opening poison is passed into it, flowing out again by the lower aperture placed near but not actually at the tip of the fang. Were the opening in the latter position it would be liable to blockage, but as it is a wound can be inflicted without danger of this. The piercing tube (cannula), attached to a hypodermic syringe, such as doctors employ for injecting various solutions (morphia, &c.) under the skin, is constructed on the same principle. As often remarked, many of the products of human ingenuity are copied from or anticipated by structures possessed by the bodies of animals.

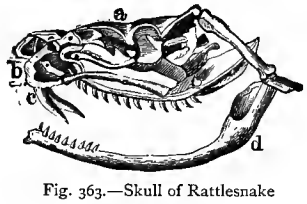


Fig. 363.—Skull of Rattlesnake
a, Brain-case; *b*, maxilla; *c*, poison-fang; *d*, lower jaw.

When the mouth of a viper is closed the poison-fangs are backwardly-directed and pressed closely against the palate, but when the mouth is opened a series of slender bones running forwards from the joint of the jaw pushes the movable upper-jaw-bone forwards, causing the fangs to be "erected", *i.e.* rotated downwards and forwards, so that they are ready for use. Closure of the mouth reverses the action, enabling the snake to "strike" or bite its prey. As, too, the fangs are very brittle, and therefore liable to be broken off, a number of small "reserve fangs" are imbedded in the jaw at the base of the one actually in use, and these grow up one after another as required.

Poisonous snakes even more than some of the harmless kinds are accredited with powers of "fascination"; in other words, they appear to be able to hypnotize their prey. It has been suggested that the rapid movement of the tongue may play an important part in this process, just as in the human subject a state of trance can often be brought about by gazing at a rapidly-revolving mirror or "lark-mill".

Some of the venomous serpents are so coloured and marked that they harmonize with their surroundings; a case of "aggressive general resemblance", so called because it aids them in their pursuit of prey, which are thus apt to be caught unawares.

CHAPTER VII

THE FOOD OF ANIMALS—AMPHIBIA AND FISHES OF CARNIVOROUS AND INSECTIVOROUS HABIT

AMPHIBIA

We find the members of the class AMPHIBIA preying upon insects, worms, snails, and the like, both on land and in fresh water. Only a few of the more striking adaptations in the group will be mentioned, and in this connection one of the most interesting species is the common Grass Frog (*Rana temporaria*). Like the Chameleon, this animal is capable of changing its hue according to the nature of its surroundings for the time being, the alteration in colour being, however, less rapid. The Frog also possesses a sticky tongue, which can be shot out for some distance for the purpose of catching insects, but the mechanism is somewhat different from that present in the Chameleon. The tongue here is forked, not club-ended, and when not in use is directed backwards, its attached part being fixed to the floor of the mouth far forwards. When shot out, an action which can be very rapidly effected, its tip brushes past the front part of the roof of the mouth, taking up some of a sticky fluid which exudes from some special glands belonging to that region (fig. 364). The tongue is then quickly drawn back into the mouth, carrying the catch with it.

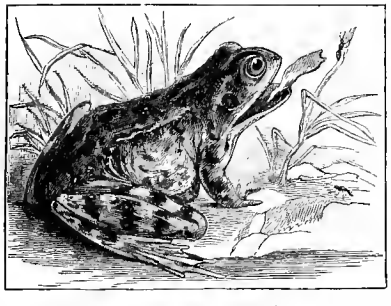


Fig. 364.—Tongue of Frog extended to secure its Prey

The Common Toad (*Bufo vulgaris*) captures prey much in the same way as the Frog (fig. 365), and it is also fond of worms, tackling even large ones with the aid of its feet.

Some of the tailless Amphibians, such as the Tree-Frogs, of which a little green species (*Hyla Europea*) is well known on

the continent of Europe, are aboreal in habit, and harmonize in colour with the foliage which surround them.

Tailed Amphibians differ a good deal among themselves as regards their habits. Some of them, as the Spotted Salamander (*Salamandra maculosa*) (see vol. i, p. 246), devour snails and such other small invertebrates as are to be found in damp places on the land, while many are aquatic, among these being the Newts and Fish-like Salamanders.

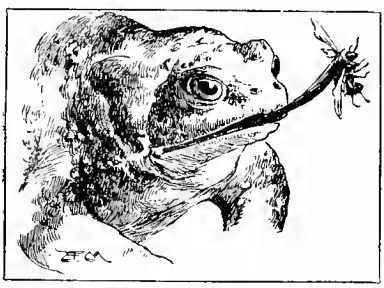


Fig. 365.—Toad catching its Prey

Cases have already been noted of snakes and snake-like lizards which burrow in the earth, and this habit also finds illustration among the Amphibia in the case of the blind and limbless Cæcilians (see vol. i, p. 255), which possess long worm-like bodies, and pursue earthworms, &c., underground.

FISHES

The enormous class of Fishes is pre-eminently carnivorous, and its members present many interesting structural features having reference to the nature of the food. The several orders may be considered in succession.

LUNG-FISHES OR MUD-FISHES (Dipnoi)

The Lung-Fishes or Mud-Fishes (Dipnoi) (see vol. i, p. 265) of Africa, South America, and Australia, are all carnivorous, and their mouths are armed with broad bony plates suited for crushing. The South American Mud-Fish (*Lepidosiren*) of the Amazon and Paraguay rivers has been shown, in the latter locality at least, to feed very largely upon a large kind of fresh-water snail (*Ampullaria*), the shells of which are easily crushed by these strong dental plates. The habits of the African Mud-Fish (*Protopterus*), judged by the behaviour of captive specimens, are in many respects similar, but their diet would appear to be of a more varied character. Semon (*In the Australian Bush*) makes the following remarks about the food of the Australian Mud-Fish (*Ceratodus*):—"Now and then our baits of meat or molluscs

attracted a Ceratodus, and this proved that the Australian lung-fish is by no means a vegetarian, as has hitherto been thought. On opening the animal, the intestinal canal will indeed almost always be found filled with green vegetable matter, partly composed of leaves and blossoms of gum- and tea-trees, carried into the river by the wind, partly of genuine water-plants. But noting that Ceratodus took so well to animal bait, I grew doubtful whether the above-mentioned plants are eaten for their own sake, or for the sake of the many little animals: craw-fish, worms, snails, shell-fish, and insect-larvæ, which they harbour. On examining the contents of the intestines, I found that the tough fibres of the plants are not digested, but leave the body in an almost unchanged state. They are, so to say, but the vehicles of the food itself, which is of essentially animal character."

ORDINARY BONY FISHES (TELEOSTEI)

The ordinary Bony Fishes (Teleostei), which include the vast majority of existing piscine forms, present many examples of special adaptations to an animal diet. A very large number of species are provided with numerous small, pointed teeth, which are of no use for masticatory purposes, but constitute an efficient seizing apparatus, fatal to many sorts of prey, from other fishes downwards. Among common predaceous species which possess numerous teeth of this kind are the Fresh-water Perch (*Perca fluviatilis*) and its many allies, the members of the Mackerel Family, and the voracious Pike (*Esox lucius*). It is the rule for the teeth to be backwardly-directed, so that the prey cannot escape after having been once secured.

Lures.—A further specialization in the direction just indicated is found in the ugly Angler-Fish or Fishing-Frog (*Lophius piscatorius*) (fig. 366), common in shallow water round our coasts. Here the huge mouth is beset with large, pointed teeth of various sizes, those in front being hinged on the jaws so that they are easily pressed down to admit of the entry of prey, for which, however, exit is quite another matter, as, after depression, the teeth spring up again by the action of elastic ligaments. This ungainly fish lurks on the bottom, with which it harmonizes in colour, the hue being capable of alteration to suit different surroundings (aggressive variable coloration). Its paired fins are

used for crawling, and also for heaping up loose material around its body. When in wait for prey it remains motionless, and there are tags of skin attached to the margins of the jaw which float out and look like bits of sea-weed. And further, it is possessed of a fishing-rod carrying a "lure", for the long spines of the first dorsal fin are unconnected by membrane, and the first of

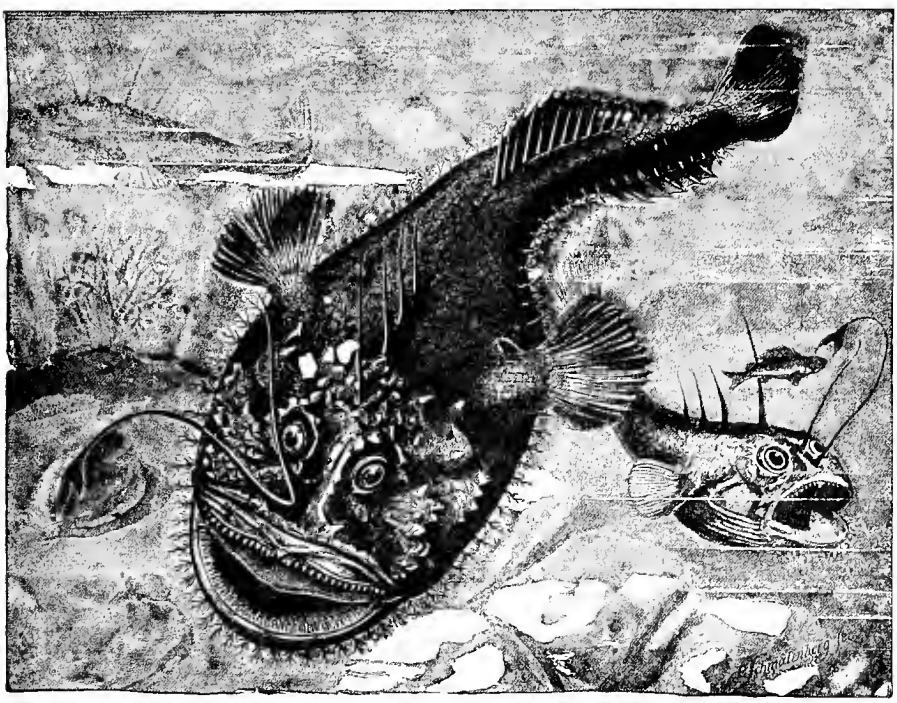


Fig. 366.—Angler-Fish (*Lophius piscatorius*)

them broadens out into a sort of flap, which waves about a little way above the mouth, exciting the curiosity of smaller fishes. If these are so foolhardy as to venture near, the Angler makes a sudden spring and engulfs them in his capacious mouth.

A still more remarkable arrangement as regards the "lure" is to be found in a related species, the Deep-sea Angler (*Melanocetus Murrayi*) (fig. 367), which inhabits depths of from 1850 to 2450 fathoms. The arrangement is described in the following quotation from Hickson (*The Fauna of the Deep Sea*):—"The eyes are very small indeed, the mouth huge and armed with long, uneven, rasp-like teeth. At the end of the fishing-rod tentacle hanging over the mouth there is an organ that has been

supposed to be capable of emitting a phosphorescent light. This curious modification of the red-worm-like bait of the common shallow-water angler into a will-o'-the-wisp lantern, attracting little fishes to their destruction in the deadly jaws of the *Melanocetus*, is one of the most interesting adaptations that has been brought to light by our study of the deep-water fauna."



Fig. 367.—Deep-sea Angler (*Melanocetus Murrayi*)

Crushing Teeth.— Many bony fishes feed upon molluscs, hard-shelled crustacea, and other creatures which require crushing before they can be digested, and in these forms the teeth, or some of them, are converted into firm plates suitable for mastication. Such teeth are present in the Wrasses, shallow-water species which feed on crustaceans, molluscs, and in some cases on corals. Many of these fishes are provided with a strong, curved upper tooth at each angle of the mouth, the use of these being to hold the food in position between the crushing front and side teeth. Attention may also be called to the voracious Wolf-Fishes (*Anarrhichas*), gigantic members of the Blenny Family, which inhabit the northern parts of the great oceans. In these creatures not only are the margins of the jaws provided with strong blunt teeth, but there is also a longitudinal band of similar teeth on the palate.

Electric Organs.—Certain fishes are provided with electric organs, with which they are believed to kill or stun their prey, and which have been produced by modification of some of the muscles (fig. 368). Those belonging to the group now under consideration are inhabitants of fresh water. They include the Electric Cat-Fishes of tropical Africa and the Electric-Eel from tropical South America. The last may be as much as 6 feet in length.

Shore-Hunters.—Widely distributed along the tropical and temperate coasts of the world are to be found the Gobies, which constitute a family of small carnivorous species. Some of these, known as Mud-Skippers, abound in the Indo-Pacific region and are represented on the west coast of Africa, one extremely common kind from the former area being *Periophthalmus Kœlreuteri.* This, like the other allied species, instead of keeping to its own proper element, makes a hunting-ground of the shore between tide-marks, especially when it is muddy or uneven, and littered with brown sea-weeds or mangrove roots. Progressing by a series of hops, effected by means of the tail and strong, paired fins, it pursues relentlessly small crabs and other invertebrates, and such insects as mosquitoes have been found in its stomach. The large protruding eyes are capable of very free movement, and an investigation of their structure has shown that they are as useful on land as in the water.

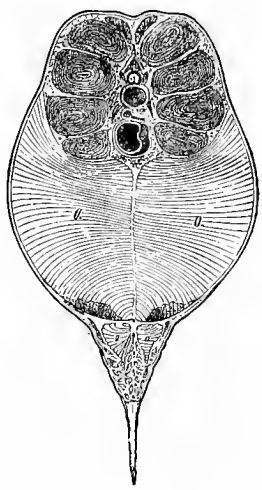


Fig. 368.—Cross-section through Electric Eel

o o, Electric organ, above which on either side are seen four masses of muscle (darkly shaded). The wedge-shaped structure below is the ventral fin.

Insect-Eaters.—Insects are included in the diet of the last-named fish, and it is, of course, a common thing to see fish rise at "flies" which fall into the water, but a much more interesting case is that of the Beaked Chelmon (*Chelmon rostratus*), an inhabitant of Indian rivers and estuaries. It possesses a long tubular snout, from which it is said to be able to eject drops of water for a distance of several feet with considerable force, the object being to knock into the water insects which have alighted on vegetation near the edge.

Use of Sense Organs.—Among the higher back-boned animals cases have been cited where the senses of touch, smell, and sight respectively are of importance in the detection or pursuit of prey. Ducks, dog-like animals, and vultures may be mentioned as typical instances. Fishes afford examples of all three cases, but it will be convenient to postpone details till organs of sense are dealt with in a later section.

SHARKS AND RAYS (ELASMOBRANCHS)

Typical Sharks.—The order of Elasmobranch fishes, including Sharks, Rays, and their allies, is essentially a predaceous one. In such a typical member of the group as the Blue Shark (*Carcharias glaucus*) (see vol. i, p. 285) the jaws are found to be armed with numerous rows of sharp triangular teeth, forming very efficient offensive weapons. The large mouth is situated far back on the under side of the head, a fact which accounts for the well-known habit this and other sharks have of turning over on their backs before seizing prey. This particular species commonly attains the length of 15 feet, while allied species may be as much as 25 feet long. Much larger proportions are exhibited by the Rondeletian Shark (*Carcharodon Rondeletii*), which has a wide distribution throughout the hotter parts of the ocean, and for which a length of 40 feet is recorded. It must not, however, be supposed that the size of the prey is proportionate to the size of the shark, or that all large species are dangerous to man. The size and character of the teeth afford a much safer guide to the habits. For example, the Basking Shark (*Cetorhinus maximus*), which is the biggest of its kind to be found in the North Atlantic, attaining as it does a length of 30 feet or more, is perfectly harmless if left alone, and feeds upon comparatively small animals. In accordance with this its numerous conical teeth are of small size.

"Shepherding" of Prey.—Another interesting species with relatively small teeth is the Thresher (*Alopecias vulpes*), distinguished by the extreme length of the upper lobe of its tail, which is longer than the rest of the body. The food consists of fish which swim in shoals, such as herrings, and the common name indicates the function of the long tail, which is used as a flail to beat the water, so that the frightened prey may be induced to herd closely together, with the result that their capture is easy.

Saws.—Teeth are by no means the only weapons of offence possessed by the Shark tribe. In Saw-Fishes (*Pristidæ*), for example, which are widely distributed through the hotter parts of the sea, and are known to ascend some of the Indian rivers, the snout is drawn out into a long flattened process armed on either side with a row of powerful tooth-like scales, that have nothing to do with the ordinary jaw-teeth (fig. 369). Such

"saws" are among the common objects seen in museums, or brought home by sailors. Powerful side-strokes can be given

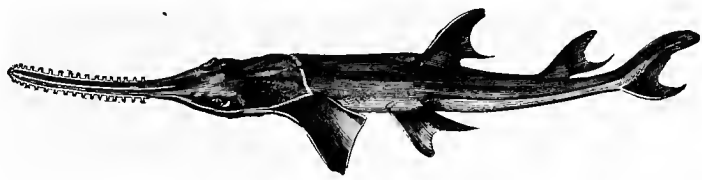


Fig. 369.—Saw-Fish (*Pristis antiquorum*)

with these formidable weapons, which in extreme cases may be 6 feet long.

Crushing Teeth.—Some sharks present a parallel to the arrangements already described for Wrasses and Wolf-Fishes, their teeth having broad crushing crowns adapted for breaking the hard investments of various invertebrates. An example is furnished by the Port Jackson Shark (*Cestracion Philippi*)

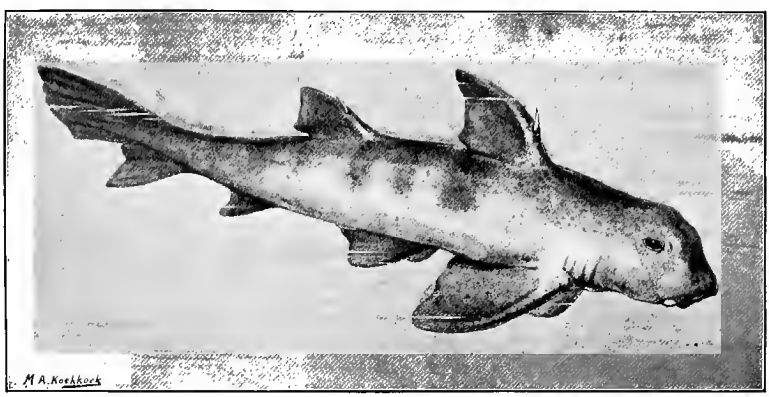


Fig. 370.—Port Jackson Shark (*Cestracion Philippi*)

(fig. 370), which feeds upon molluscs, and in which the mouth is placed at the front end of the head, a more convenient place than is usual among sharks. In this fish the front teeth are small and pointed, while the remainder are adapted for crushing.

Rays and Skates (see vol. i, p. 289) are bottom-fishes, incapable of swimming with the rapidity characteristic of typical sharks. They therefore, as might be expected, feed chiefly upon invertebrates, in accordance with which their numerous rows of closely-packed teeth are small in size. In such cases as the Eagle-Ray (*Myliobatis aquila*) (fig. 371) the teeth are broadened out

into six-sided plates, united along their edges, and forming a sort of pavement well suited for crushing purposes. In some of

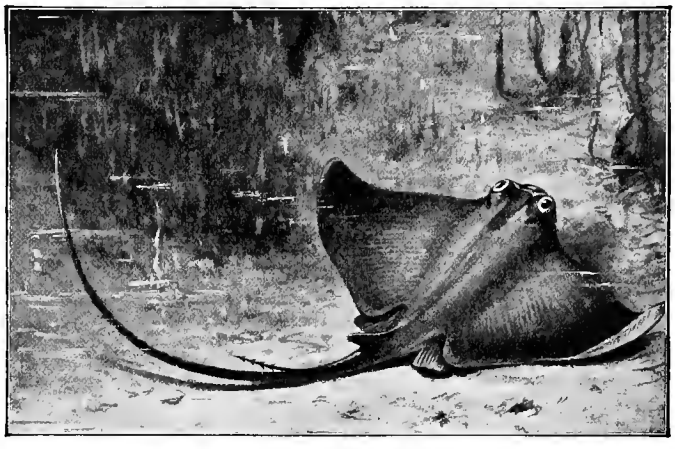


Fig. 371.—Eagle Ray (*Myliobatis aquila*)

the allied species there is an arrangement supposed to compensate for the inconvenient position of the mouth, which is not only placed far back on the under side, but also, owing to the flattening of the body, does not extend to the sides. The specialization in question consists of a horn-like projection on either side formed from a part of the pectoral fin. These horns are supposed to play the part of hands, and convey food to the mouth.

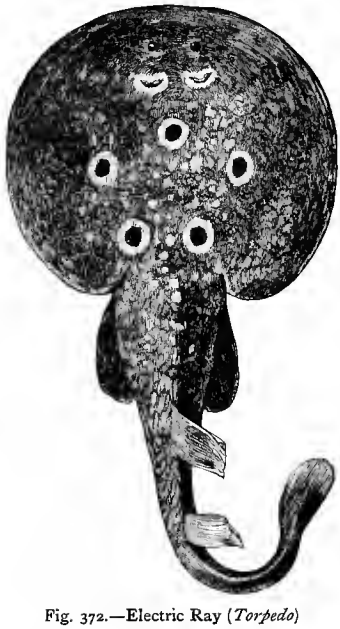


Fig. 372.—Electric Ray (*Torpedo*)

Some of the Rays, however, are enabled by special devices to prey upon fishes capable of much swifter movement than they are themselves. The colour and markings of the upper surface, for instance, may be such as to bring about so close a resemblance to the adjacent sea-bottom that other fishes venture within reach; and, further, some Rays have slender tails provided with sharp spines, enabling them to seize and wound their prey (fig. 371). The Electric Rays (fig. 372), of which a common type is the marbled species (*Torpedo marmorata*), are

provided with electric organs, by which other fishes may be killed or rendered powerless.

ROUND-MOUTHS (CYCLOSTOMES)

The lowest Vertebrates which have any claim to be included among the fishes are the Round-Mouths or Cyclostomes, including the Lampreys and Hags, which have a wide distribution in both hemispheres. They are eel-like creatures, remarkable for the absence of a lower jaw, so that they are unable to bite in the ordinary sense of the word. Notwithstanding this, they are essentially carnivorous in habit, and prey upon other fishes. If, for example, we examine the common fresh-water Lampern (*Petromyzon fluviatilis*) (see vol. i, p. 291), or the larger Sea Lamprey (*P. marinus*), we shall find that the mouth opens in the middle of a large bell-shaped sucker, studded with horny teeth. A muscular projection, the tongue, also provided with powerful teeth, can be alternately protruded from and withdrawn into the

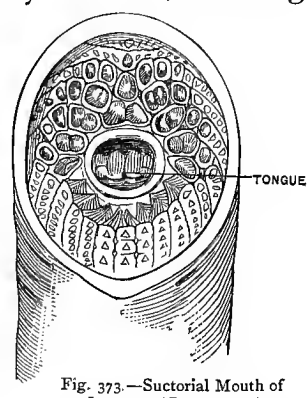


Fig. 373.—Suctorial Mouth of Lamprey (*Petromyzon*)

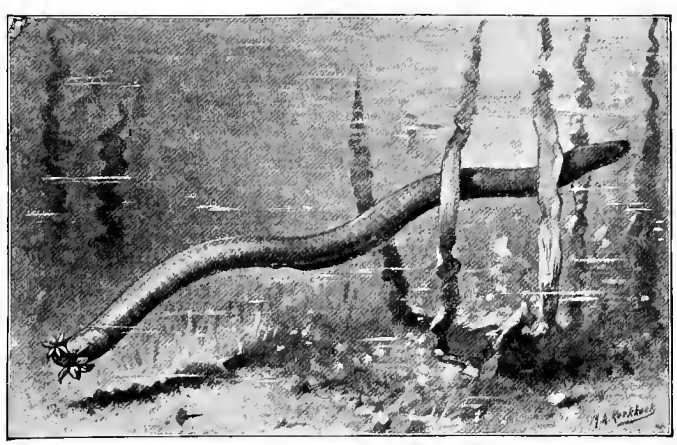


Fig. 374.—Hag-Fish (*Myxine glutinosa*)

mouth. The sucker is firmly attached to the prey, and the tongue is then used as a rasp for scraping away parts of the flesh (fig. 373).

Still more specialized is the Hag-Fish (*Myxine glutinosa*) (fig. 374), in which the degenerate and useless eyes are sunk

below the skin, and which possesses the unpleasant property of secreting enormous quantities of slime by means of the glandular skin. This creature is able actually to bore into the bodies of other fishes, though the common idea that a cod can swim about with a hag-fish half-imbedded in it rests on slender foundation. The fact appears to be that when cod are caught on deep-sea lines they are often attacked by the hag, which bores some distance into them before they are pulled up.

PRIMITIVE VERTEBRATES

The lowly Vertebrates, or more properly speaking Chordates, which are inferior in the scale to Fishes, feed to a large extent on animal matter, but as their diet is also in part of plant nature it will be best to leave them till omnivorous forms are described.

CHAPTER VIII

THE FOOD OF ANIMALS—NEMERTINES AND CARNIVOROUS MOLLUSCS

Having briefly dealt with Vertebrates, we now proceed to the consideration of the food and feeding habits of carnivorous Invertebrates, beginning with NEMERTINES, and taking next the great phylum of MOLLUSCA.

NEMERTINES

These curious worm-like marine forms, which have been described elsewhere as regards their structure (see vol. i p. 306), are purely carnivorous, preying upon all sorts of creatures, both alive and dead. The mouth and front part of the digestive tube are capable of a large amount of dilatation, enabling comparatively large bodies to be swallowed with ease. The most remarkable peculiarity of these animals is the possession of a long tubular "proboscis", which, when not in use, is contained in a sheath running along the upper side of the body, from which it can be shot out with great rapidity through a small hole situated in most cases in front of the mouth, though sometimes placed within it. The proboscis appears to be used for seizing food, and in a large number of forms its tip is provided with a sharp stylet, at the base of which poison-glands open (fig. 375). This is probably to be regarded as a means of overpowering prey.

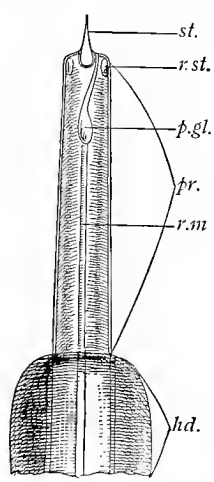


Fig. 375.—Front End of Nemertine, with proboscis partly protruded. Seen from above (diagrammatic)

hd, Head; *pr*, proboscis; *st*, stylet; *r.st*, one of the two sacs containing reserve stylets; *p.gl.*, poison-gland; *r.m.*, retractor muscle.

CARNIVOROUS MOLLUSCS

CUTTLE-FISHES AND SQUIDS (CEPHALOPODS)

The members of the highest class of Molluscs, the head-footed creatures embraced under the term Cephalopoda, are essentially rapacious, and typical in this respect are the Cuttle-Fish (*Sepia officinalis*), the Squid (*Loligo vulgaris*), the Octopus or Poulpe (*Octopus vulgaris*), and the Musky Octopus (*Eledone moschatus*). In the absence of limbs these creatures possess very effective weapons of offence, formed by modification of a part of the typical molluscan organ known as the *foot*, and which in its simplest form, as seen in a common snail, consists of a muscular outgrowth from the under side of the body, presenting a creeping sole-like surface. In the case of, say, a cuttle-fish, the front part of this foot has grown round and fused with the head, hence the name *head-footed* molluscs. And this region is drawn out into a number of slender *arms* capable of being stretched out till they look like whip-lashes, there being eight of them in an octopus and ten in a cuttle-fish. In the latter, two of the arms are much longer than the rest and expanded at their ends, while they can also be drawn back into special pouches. The mouth of the animal is situated between the bases of these arms. (See vol. i, fig. 179.)

Not only are the arms extremely extensible and capable of being twined around any animal attacked, but they are studded on their inner sides with *suckers* (stalked in cuttle-fishes, unstalked in octopi), by means of which a most tenacious grip is maintained. Each sucker is a little cup, the margin of which is provided with a toothed horny ring for the prevention of slipping, and within which is a muscular projection that can be drawn back piston-like so as to produce a vacuum. After being seized by the arms the prey is drawn to the mouth, which is furnished with a pair of strong horny jaws closely resembling the beak of a parrot (fig. 376). After this has fixed itself firmly to the body of the animal the rasping organ is brought into action, and this structure is so important that it merits a somewhat detailed description.

A rasping organ, or, to use the technical term, *odontophore* (Gk., *odous*, *odontos*, tooth; *pherō*, I bear), is eminently characteristic of all the Mollusca, with the exception of the bivalve forms, and is just as useful to the vegetarians as to the carnivorous

species. It consists of (vol. i, fig. 199) a cushion rising up from the floor of the mouth, and supported by hard parts of a gristly nature. Stretched over this swelling from front to back is a horny ribbon-shaped structure, the *radula* (L. *radula*, a scraper), the surface of which is beset with regular rows of small, sharp, horny teeth. By means of appropriate muscles the odontophore can be somewhat protruded, so as to press against the object to

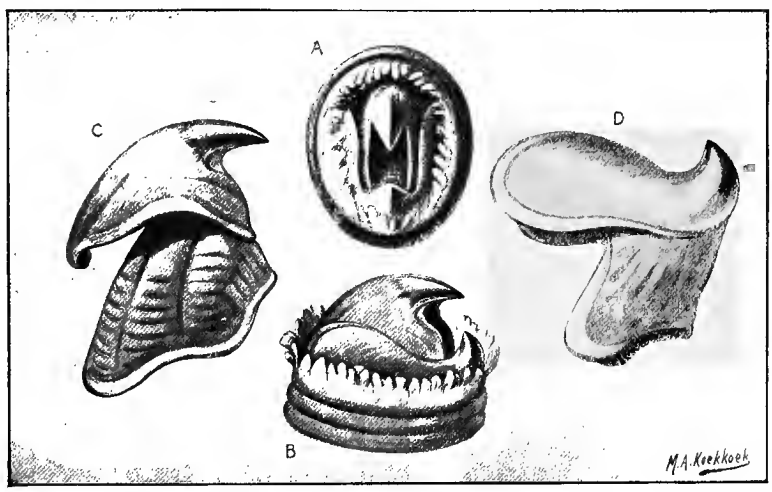


Fig. 376.—Beaks of Cuttle-Fish (*Sepia officinalis*)

A, From below (the radula on its cushion is seen within). B, From the side. C, Lower beak. D, Upper beak.

be rasped, and there are also muscles by which it can be drawn back again and put out of action when required. Within the cushion of the odontophore are other small muscles for working the radula (which rests loosely upon its support) backwards and forwards, after the manner of a chain-saw, so as to rasp very effectively anything to which it may be applied. The gristly supports of the odontophore give points of attachment to these little muscles. After a certain amount of work the teeth of the radula become blunt and worn, but this contingency is provided for, as the ribbon is continually growing forwards, much like a finger-nail. And just as by gently moving a finger-nail up and down you can see that it runs back under a fold of skin to a "root" where new nail is constantly being formed, so can the radula be followed back into a projection, the *radula sac*, out of which it is continually growing. This toothed ribbon, which constitutes the actual scraping part of the odontophore, is often called

the "tongue" or "palate", and will usually be found described as such in catalogues of microscopic objects. It is of importance in classification, for the teeth vary in number, nature, and arrangement in different species.

SNAILS AND SLUGS (GASTROPODA)

From Cephalopods we pass on to the enormous group of Snails and Slugs, *i.e.* to the Gastropoda, of which vast numbers are carnivorous. It is interesting to note that by cursory inspection of the empty shell it is possible to tell whether the inhabitant subsisted on animal or vegetable matter, for in the former case the opening or mouth is notched, in the latter continuous or entire. The notch is for the protrusion of a tubular organ (the siphon) related to the breathing function, and which will be described in a subsequent section. The teeth in the radula of a carnivorous gastropod are usually comparatively few and specialized. Their form is often strongly curved, or it may be hook-like (fig. 377).

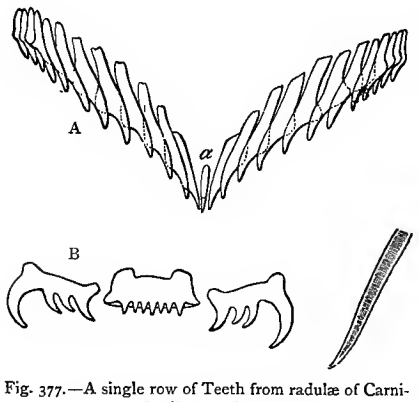


Fig. 377.—A single row of Teeth from radulæ of Carnivorous Snails (greatly enlarged)

A, From Glandina (a land-snail). B, From Whelk (*Buccinum undatum*). On the right is shown the entire radula (natural size).

One of the commonest and most voracious inhabitants of the zone between tide-marks round the British coasts is the Purple-Shell (*Purpura lapillus*) (fig. 378). This is possessed of a protrusible snout, armed with a strong odontophore, and it plays havoc with other Gastropods and with Bivalves, especially mussels, These may either be attacked through the opening of the shell, or, failing this easy path, the Purple-Shell bores through the firm investment of its prey. One commonly picks up the loose shells of small bivalves in which a neat round hole has been drilled, and as often as not this has been the work of a Purpura. These snails may also be found crawling about projecting rocks studded with acorn barnacles, the firm shells of which they perforate in much the same way and with the same object in view, and a little careful observation will often result in the detection

of the aggressors actually at work. The rasping noise made by the radula as it bores through the barnacle's shell is readily audible.

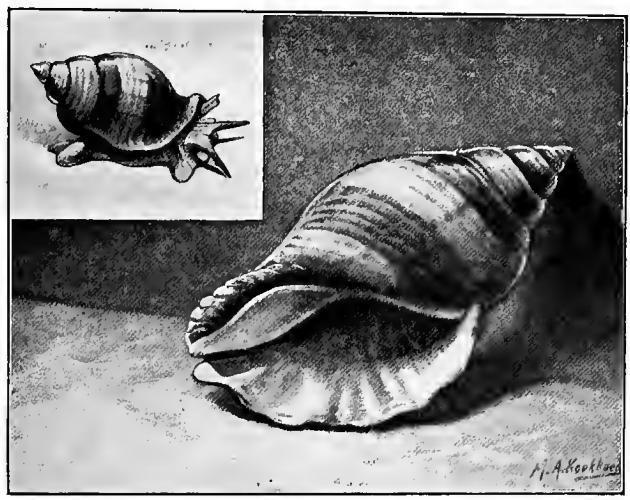


Fig. 378.—The Purple-Shell (*Purpura lapillus*). The small figure shows an individual crawling.

Another common carnivorous sea-snail, much larger than the Purple-Shell, and rapacious in proportion to its size, is the Common Whelk (*Buccinum undatum*) (see vol. i, p. 321), abundant in shallow water. The rasping apparatus is lodged in the tip of a very long narrow proboscis, which can either be protruded or drawn completely back into the body. Whelks chiefly prey upon bivalve molluscs, even some of the burrowing species not being exempt from its attacks, and it is one of the many enemies of the oyster.



Fig. 379 Barbed Poison-tooth from radula of a Cone. At the base is seen the poison-gland, the duct of which runs within the tooth and opens near its tip.

The Cone-Shells, most of which are tropical, are interesting in the present connection because the bite is poisonous in some, perhaps all, of the species (fig. 379). That any sort of sea-snail should bite a human being seems at first sight somewhat singular, but Cone-Shells, when incautiously handled, have done so, and this led to the discovery that some of these forms are poisonous.

Method of Shell-boring.—Such molluscs as the Purple-Shell, Whelk, &c., are commonly supposed to depend entirely on the radula as a means of penetrating the shells of their victims. It certainly does assist in the process (see above—Purple-

Shell). Unaided, however, this structure does not seem powerful enough for the purpose, and even if it were, it is difficult to see how a ribbon-shaped organ could be employed to bore a round hole. The matter has been carefully investigated (by Schiemenz) in a species of Natica (*N. Josephina*) (fig. 380), a sea-snail possessed of a very large foot, by means of which it burrows in the sand in pursuit of the bivalves upon which it chiefly feeds, and which are commonly found buried in an oblique position, with the posterior end projecting at the surface. The Natica appears to detect its prey by means of the sensitive front-end of its foot, which is then folded back so as not to interfere with the action of the proboscis, and at the same time co-operates with the rest of the foot in grasping firmly the front end of the unfortunate bivalve. The proboscis is now protruded, and close to the under side of its tip the true boring organ is seen as a circular disc, upon the surface of which a large number of little glands open. This structure is applied to the shell to be perforated, and an acid fluid is poured out from it which dissolves the shell over a small circular area of corresponding size and shape. As soon as a hole has been made, it would seem that the radula helps to enlarge it, and is afterwards used for rasping the flesh of the prey through the breach made in its defences (fig. 381). The exact mode of procedure in Whelk, Purple-Shell, &c., has not yet been determined, but there is little doubt that an acid secretion is brought into play. It is well known that the so-called salivary glands of a number of the predaceous sea-snails contain an appreciable quantity of free sulphuric acid, and it is suggested that

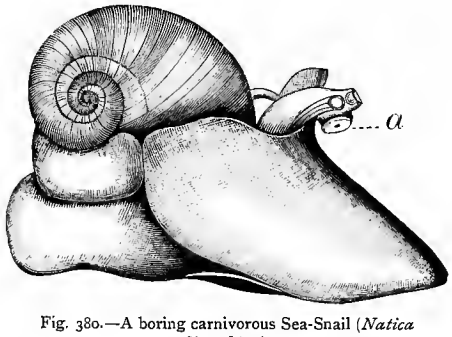


Fig. 380.—A boring carnivorous Sea-Snail (*Natica Josephina*)

The front of the foot is folded back, and above it is seen the projecting snout with boring organ (*a*).

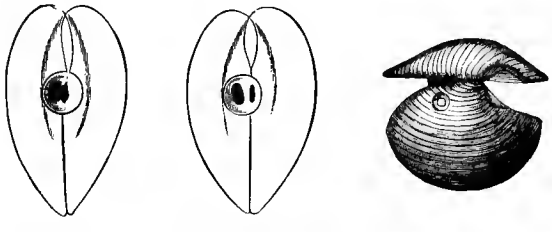


Fig. 381.—Bivalve Shells bored by Natica

this is used to eat away the shells of the molluscs, &c., attacked by such creatures. This is a good example of the numerous cases where our knowledge of the habits of common animals is woefully incomplete, and is just the kind of problem which might be attacked with fair chance of success by local natural history clubs, given patience and the power of accurately observing details. Most professional zoologists, unfortunately, are too much taken up with laboratory work to attend to such matters, though the study of animal habits is perhaps the most interesting branch of their subject.

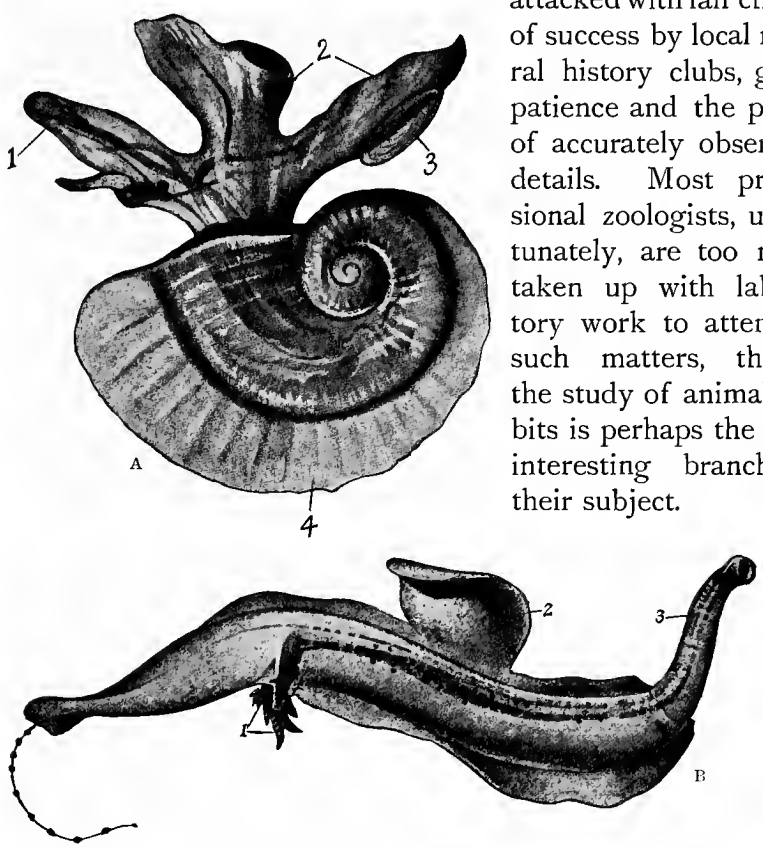


Fig. 382.—Heteropods

A, Atlanta: 1, snout; 2, foot; 3, operculum; 4, shell. B, Pterotrachea: 1, gills; 2, foot; 3, snout. These creatures swim upside down as represented.

HETEROPODS.—Among predaceous Gastropods are the free-swimming marine forms known as Heteropods (fig. 382), in which the foot is more or less completely transformed into a fin, by means of which the animal swims with its upper surface directed downwards. Like animals of pelagic habit generally they are of almost glass-like transparency, and may or may not be provided with a shell. Atlanta, for example, has a spiral shell, Carinaria a cap-shaped one, and Pterotrachea none at all. They possess a long snout, in the end of which the rasping organ is

lodged, and prey upon jelly-fish and other floating forms with which they are associated on the high seas.

TECTIBRANCHS.—So far examples have been given of the *fore-gilled* Gastropods only, but carnivorous types are found among the *hind-gilled* subdivision as well. The Tectibranch members of the group are provided with a shell, though this may in some cases be a mere plate sunk below the surface to a greater or less extent. The burrowing form, Scaphander, is a good example of quite a different mode of procedure from that adopted by whelk, &c., for instead of boring holes in the shells of comparatively large animals, it selects for its prey small molluscs and the like, which can be conveniently swallowed whole, after which they are crushed by the action of a powerful gizzard armed with firm calcareous plates. Similar in habit and structure are the Bubble-Shells (see vol. i, p. 324); and so is one of the most abundant British Tectibranchs, *Philine aperta*, a little white creature with its delicate shell completely hidden from view, and which feeds very largely upon Foraminifera.

SEA-SLUGS (Nudibranchs).—Some of the Sea-Slugs, constituting the shell-less Nudibranch section of the hind-gilled group, are also flesh-eaters. An instance is Æolidia, in which the body is studded with tentacle-like outgrowths, and which chiefly attacks soft creatures like sea-anemones. It is not uncommon between tide-marks on some parts of our coast. A related genus, Glaucus, is of a beautiful blue tint, and drifts about in the open sea attached to sea-weed. It preys upon jelly-fish and the like.

LUNG-SNAILS (*Pulmonates*).—Though most of the *lung-breathing* Gastropods, including the land-snails and slugs, as well as some of the freshwater snails, feed upon vegetable substances, there are some kinds which are exclusively carnivorous. Among these may be mentioned certain slugs belonging to the genus Testacella, in which there is a small cup-shaped shell borne on the tip of the tail. These creatures are among the many enemies of earth-worms, which they pursue underground.

BRITISH SEA-SLUGS (*Nudibranchs*)

(After Alder and Hancock.) Drawn to various scales

These beautiful little creeping Molluscs are devoid of shells, nor do they possess the typical gill-chamber with gills characteristic of their allies the Sea-Snails. Some, however, are provided with a circlet of feather-like breathing-organs surrounding the intestinal aperture (see 1, 2, 4). Together with (see 1 and 2), or in the absence of these (see 3 and 5), there may be a varying number of simple or branching outgrowths (cerata) from the upper side of the body, which are provided with defensive stinging-organs.

Nudibranchs are either coloured so as to harmonize with their surroundings ("general protective coloration"), or in such a way as to make them very conspicuous ("warning coloration"). The latter state of things advertises unpleasant properties by way of smell or taste, and gives a certain amount of protection against fishes, &c.

1. *Triopa claviger.*
2. *Thecacera pennigera.*
3. *Eolis coronata.*
4. *Doris coccinea.*
5. *Doto coronata.*



BRITISH SEA-SLUGS (NUDIBRANCHS)

1. Triopa claviger. 2. Thecacera pennigera. 3. Eolis coronata.
4. Doris coccinea. 5. Doto coronata.

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CHAPTER IX

THE FOOD OF ANIMALS—CARNIVOROUS INSECTS

The huge phylum of ARTHROPODA embraces an extraordinary variety of forms adapted to life under the most diverse conditions, and frequently of carnivorous habit. The most characteristic feature in all these animals is the possession of paired, jointed limbs, specialized for the performance of various functions. Some are used in locomotion, others serve as weapons of offence and defence, and others again act as jaws. The nervous system and sense organs are exceedingly well developed, and this is associated with extreme activity and, in certain cases, with intelligence of a high order.

Arthropods are divided into two great groups—one of AIR-BREATHERS (Tracheata), including Insects, Scorpions (and their allies), Centipedes and Millipedes, and the primitive form Peripatus; the other of aquatic GILL-BEARING FORMS (Branchiata), embracing Crustacea and their allies. It will be convenient to begin with Insects and finish with Crustacea.

INSECTS (INSECTA)

Insects include the large majority of land animals, and of all terrestrial invertebrate groups have been most successful in the struggle for existence. This no doubt results from their great activity, which in its turn is dependent upon very perfect arrangements for purifying the blood and introducing fresh oxygen into the system. Nor must it be forgotten that most members of the class are endowed with the power of flight, which is in itself a great advantage, especially in the search for suitable food. The possession of this power largely accounts for the wide distribution of the group. A simple and typical insect, the Cockroach, has been described at some length in vol. i, p. 343, and it is not necessary to repeat much of what was there said, though a few of the more salient points may with advantage be reviewed. The body of an insect is clearly divided into three distinct regions:

(1) the head, provided with feelers (antennæ), eyes, and other sense organs, and bearing three pairs of limbs specialized as jaws; (2) the thorax, carrying three pairs of legs and two pairs of wings; and (3) the abdomen, devoid of obvious limbs, though modified traces of these are usually present at the hinder end. For our present purpose the jaws merit special attention. They are known as mandibles, first maxillæ, and second maxillæ, when taken in order from front to back, and are clustered together in the neighbourhood of the mouth-opening, the first pair of them being overlapped by the second, and these again by the third. In the Cockroach they are in a comparatively simple condition: the mandibles are strong, horny jaws adapted for biting; the first maxillæ are also provided with cutting pieces; and the second maxillæ are partly fused into a sort of plate which acts as an under lip, or labium as it is often called. Jointed feelers or palps are borne by both pairs of maxillæ, and are termed respectively maxillary palps and labial palps. It should further be remarked that a broad upper lip or labrum overhangs the mouth in front, and the mandibles and first maxillæ work from side to side in the space between upper and lower lips, effectively biting anything that may happen to be between them. An insect with jaws of the sort just described is said to have biting mouth-parts; but in other cases the corresponding parts may be specialized into sucking, licking, or piercing organs, as will be shown in the sequel. Indeed, the mouth-parts of insects afford one of the best-known illustrations of modifications for special purposes based on a common type or plan of structure, a principle which frequently recurs in the animal kingdom.

The nine orders of Insects may roughly be divided into two sets, according as the mouth-parts are suited for biting or modified into suctorial structures.

A.—Insects with biting mouth-parts (in the adult).

1. MEMBRANE-WINGED INSECTS (HYMENOPTERA).—Bees, Wasps, Ants, &c.

2. BEETLES (COLEOPTERA).

3. NET-WINGED INSECTS (NEUROPTERA).—Dragon-Flies, Termites, May-Flies, &c.

4. STRAIGHT-WINGED INSECTS (ORTHOPTERA).—Cockroaches, Crickets, Locusts, Grasshoppers, Earwigs.

5. WINGLESS INSECTS (APTERA).—Primitive forms, in some of which the mouth may be imperfectly suctorial.

B.—Mouth more or less perfectly suctorial (in the adult).

6. Moths and Butterflies (Lepidoptera).
7. Flies and Fleas (Diptera).
8. Fringed-winged Insects (Thysanoptera).—Corn-Thrips, &c.
9. Bugs (Hemiptera).

The above grouping is founded on the structure of the mouth-parts in the adult, but these may be quite different in the larva, in correlation with different habits. A caterpillar, for example, has biting mouth-parts, but the corresponding organs of the moth or butterfly into which it ultimately develops are purely suctorial.

MEMBRANE-WINGED INSECTS (Hymenoptera)

This order is regarded by many authorities as the highest among insects, not so much perhaps on the ground of complexity of structure as on the score of a marvellously-developed intelligence, seen more particularly in the social species of ant, bee, and wasp. Details relating to the social economy of such forms will be given in another connection, when the association of animals is considered; here we are only concerned with the question of food. Ordinary British species are omnivorous in habit, but certain tropical forms show a marked predilection for animal food, and some of them migrate from place to place in formidable armies which make a clean sweep of everything that comes in their way.

Predaceous Ants.—This is the case, for instance, with the much-dreaded Driver-Ants (*Anomma arcens*) of West Africa, regarding which not a few unpleasant stories are current, such as the reported tying-up of criminals in their path and so forth. Their habits have been described by Savage, who states that they check "the more rapid increase of noxious insects and smaller reptiles; consume much dead animal matter, which is constantly occurring, decaying, becoming offensive, and thus vitiating the atmosphere, and, which is by no means the least important in the Torrid Zone, often compelling the inhabitants to keep their dwellings, towns, and their vicinity in a state of comparative cleanliness. The dread of them is upon every living thing. . . Their entrance into a house is soon known by the simultaneous and universal movement of rats, mice, lizards, Blapsidæ, Blattidæ, and of the numerous vermin that infest our dwellings." These

Driver-Ants are blind and do most of their hunting at night. Bates (in *The Naturalist on the River Amazons*) has graphically described the somewhat similar habits of certain South American

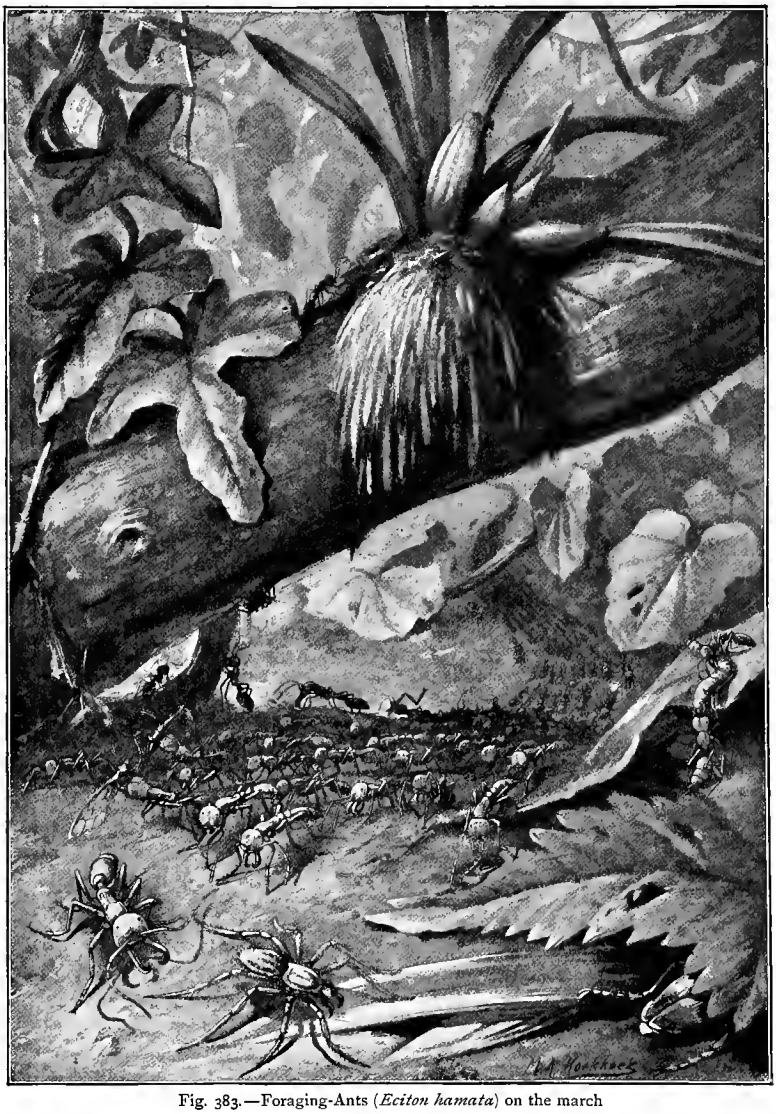


Fig. 383.—Foraging-Ants (*Eciton hamata*) on the march

Foraging-Ants belonging to the genus Eciton (fig. 383). As in so many other insect communities there are here not only males and females but also "workers", in this case of two kinds, large-heads and small-heads, the former being possessed of particularly powerful mandibles, styled simply "jaws" in most

works on natural history. It should further be noted that in most ants, as also in bees and wasps, the females and workers (which are really undeveloped females) possess a poisonous sting in the hinder-part of the body. This consists essentially of a couple of slender-toothed stylets, enclosed in a sheath, and connected with a poison-gland, of which the secretion contains formic acid, a substance which indeed owes its name to the fact that ants are the source from which it was first derived (Lat. *formica*, an ant). Bates speaks as follows of the two commonest species of these Foraging-Ants (*Eciton hamata* and *E. drepanophora*):—"These Ecitons are seen in the pathways of the forest at all places on the banks of the Amazons, travelling in dense columns of countless thousands. . . . When the pedestrian falls in with a train of these ants, the first signal given him is a twittering and restless movement of small flocks of plain-coloured birds (ant-thrushes) in the jungle. If this be disregarded until he advances a few steps farther, he is sure to fall into trouble, and find himself suddenly attacked by numbers of the ferocious little creatures. They swarm up his legs with incredible rapidity, each one driving its pincer-like jaws into his skin, and with the purchase thus obtained, doubling its tail, and stinging with all its might. . . . The errand of the vast ant-armies is plunder. . . . Wherever they move, the whole animal world is set in commotion, and every creature tries to get out of their way. But it is especially the various tribes of wingless insects [and other arthropods] that have cause for fear, such as heavy-bodied spiders, ants of other species, maggots, caterpillars, larvæ of cockroaches, and so forth, all of which live under fallen leaves or in decaying wood. The Ecitons do not mount very high on trees, and therefore the nestlings of birds are not much incommoded by them. The mode of operation of these armies, which I ascertained only after long-continued observation, is as follows:—The main column, from four to six deep, moves forward in a given direction, clearing the ground of all animal matter, dead or alive, and throwing off here and there a thinner column to forage for a short time on the flanks of the main army, and re-enter it again after their task is accomplished. If some very rich place be encountered anywhere near the line of march, for example a mass of rotten wood abounding in insect larvæ, a delay takes place, and a very strong force of ants is concentrated upon it. The excited creatures search every cranny, and tear in pieces

all the large grubs they drag to light." The same naturalist gives an account of certain blind species of these ants which construct covered roads from grains of earth, under which they march to suitable hunting grounds. For further details on this fascinating subject the original work must be consulted.

Besides predaceous social ants there are also solitary ones of similar habit, some of these being British (as, *e.g.*, *Mutilla Europæa*).

Sand-Wasps.—There are many hymenopterous insects which provide a store of suitable food for their carnivorous young,

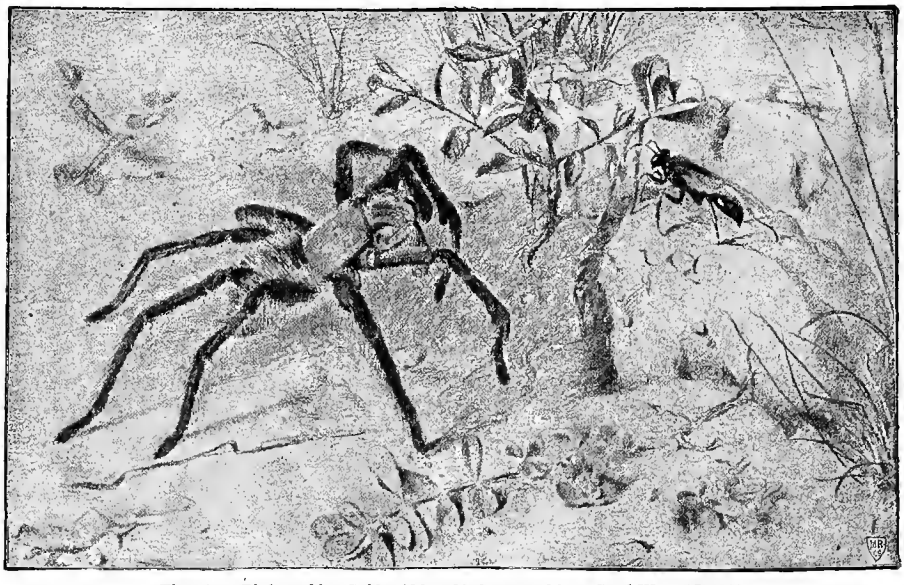


Fig. 384.—Bird-catching Spider (*Mygale*) threatened by a Sand-Wasp (*Pepsis*)

a subject which will be entered into more fully later on when the care of young is under consideration. It will suffice to say here that Sand-Wasps, solitary insects of various species, lay their eggs in holes in the ground or elsewhere, sometimes digging these out themselves, and drag into these holes caterpillars, adult insects, or spiders, previously stinging them in the nerve-cord so as to paralyse but not kill them. Different species of wasp select different victims for the purpose. The Common Sand-Wasp (*Ammophila sabulosa*) prefers caterpillars, the Path-Wasp (*Pompilus viaticus*) spiders, and the Field Sand-Wasp (*Mellinus arvensis*) flies.

Fig. 384 represents a huge South American spider (*Mygale*) threatened by a large wasp (species of *Pepsis*) of this kind.

ICHNEUMON-FLIES.—The provision made for their young by the large group of Ichneumon-Flies is still more remarkable, for in this case the female deposits her eggs in the bodies of insect-larvæ, especially caterpillars. When these eggs hatch out, an abundant food-supply surrounds them, in the form of the stores of reserve material which are laid up for use when the adult stage is gradually being shaped in the chrysalis.

BEETLES (COLEOPTERA)

A large number of Beetles are carnivorous in habit, and in none of them is this more strikingly the case than in the Tiger-Beetles (see vol. i, p. 367), of which the commonest British species is the Field Tiger-Beetle (*Cicindela campestris*). This is an extremely active insect, which can run with great rapidity, and is possessed of considerable powers of flight. As is usually the case in predaceous animals, the organs of sense are well developed. The most characteristic structures present are the mouth organs, which are obviously constructed on the same type as already described for Cockroach (p. 102). The mandibles, however, are slender but powerful-curved blades, the inner edges of which present a series of sharp projecting teeth, and the biting-pieces of the first maxillæ are studded with strong bristles, while each of them ends in a movable claw. The second maxillæ are much more closely fused into a lower lip than is the case in the Cockroach. These beetles are extremely fierce, and have even been known to indulge in cannibalism. Staveley says (in *British Insects*):—"The female has often been seen to deliberately dismember and eat her husband, though it remains a puzzle to naturalists that the husband—an insect apparently equal to herself, or nearly so, in size and power—should submit to this". The larva of the Tiger-Beetle is also predaceous, lurking in a vertical burrow in the ground, and attacking small insects which happen to pass.

GROUND-BEETLES.—Most of the Ground-Beetles (*Carabidæ*) are carnivorous, and these include an enormous number of species scattered all over the globe. The Violet Ground-Beetle (*Carabus violaceus*) is often found in houses, where it preys upon crickets and cockroaches. It is nocturnal in habit, unlike the Tiger-beetle, which hunts its prey during the day. Some of the Ground-Beetles excavate burrows, at the mouths of which they wait for prey.

ROVE-BEETLES.—The Rove-Beetles (*Staphylinidæ*) constitute another very large universally-distributed family of carnivorous beetles, with slender elongated bodies and short wing-cases. A

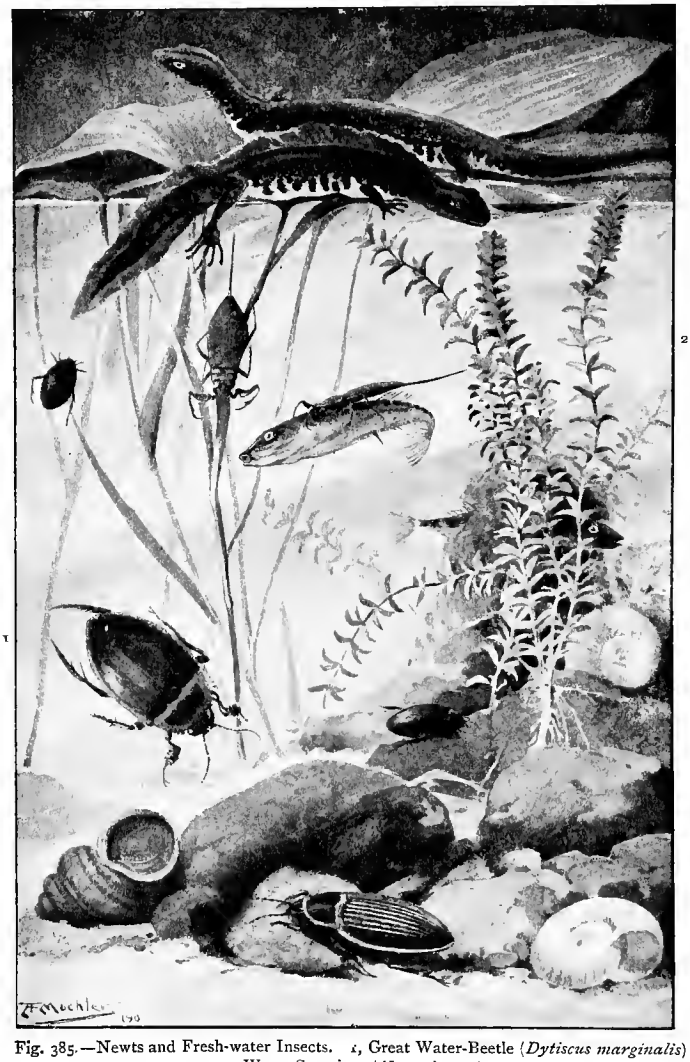


Fig. 385.—Newts and Fresh-water Insects. 1, Great Water-Beetle (*Dytiscus marginalis*) 2, Water-Scorpions (*Nepa cinerea*)

familiar native species is the Devil's Coach-Horse (*Ocypus olens*) (see vol. i, p. 368), which, like most of its kind, turns up the tip of its tail when interfered with.

WATER-BEETLES (fig. 385).—Some of the flesh-eating beetles live in fresh water, and among these is the Great Water-Beetle

(*Dytiscus marginalis*), which preys not only upon invertebrates but also upon tadpoles, newts, and small fishes. The ugly broad-headed larva is to the full as predatory as the adult, and its dull colour harmonizes with the mud on which it lives, and renders it inconspicuous to its prey. The long curved mandibles are grooved for the purpose of conducting the juices of the prey to



Fig. 386.—Scavenging Beetles

1 and 2, Burying-Beetles (*Necrophorus Germanica* and *N. vespillo*). 3 and 4, Adult and larva of black Carrion-Beetle (*Silpha atrata*). 5, Maggot-eating Beetle (*Hister quadrinotatus*). 6, Bacon-Beetle (*Dermestes lardarius*).

the creature's mouth. A still larger aquatic insect than the one just described is the Great Black Water-Beetle (*Hydrophilus piceus*), which belongs to a different family, and is interesting because it is one of the many cases in which the adult and larva differ as to the nature of the food. Here the latter is active and carnivorous, while the adult beetle feeds on vegetable matter, and in correlation with this is comparatively sluggish in its movements.

Lady-Birds.—The last predaceous beetles to be mentioned here are the pretty little Lady-Birds (*Coccinella*) (see vol. i, p. 366), which wage perpetual war upon plant-lice (aphides), more com-

monly known perhaps as "green fly". The larvæ of these beetles affect the same diet as their parents. They are bristly-looking creatures of bluish-grey colour flecked with yellowish spots.

Scavenging-Beetles (fig. 386).—Several families of Beetles include species which either in the adult or larval stage, or in both, feed upon decaying animal matter, or upon skins, food of animal origin, &c. Of these perhaps the most remarkable are the Carrion-Beetles (*Silphidæ*), among which the Burying-Beetles (species of *Necrophorus*) are well known from their habit of burying the carcasses of small mammals, birds, &c., from under which they excavate the earth, afterwards covering them over. Their eggs are laid in this carrion, which furnishes an abundant supply of savoury food to the larvæ. To the same family belong the Rove Carrion-Beetles (species of *Silpha*), of which the larvæ live, in many species, upon decaying animal matter. The members of another family (Histeridæ) were formerly supposed to feed upon the decaying matter among which they live, but it appears that this is not really the case, both adult insects and their larvæ being of predaceous habit, and preying upon fly-maggots and the like. The larvæ of one widely-distributed family of beetles (Dermestidæ) feed mainly on dried animal matter, and are found in skins, fur, and even horse-hair, while in the Bacon-Beetle (*Dermestes lardarius*) they are found in different sorts of animal food.

NET-WINGED INSECTS (Neuroptera)

A large number of the insects contained in this heterogeneous and extensive order are predaceous in habit, and in such cases the larvæ, which in many groups are aquatic, rival or excel the adults in their bloodthirsty tendencies. Among the most important members of the order living on land throughout their entire existence are the Termites and Biting-Lice. Termites, popularly known as White-"ants", will be dealt with later on, when social insects are described, and in any case only need passing mention here, since wood is the staple of their diet, though they are also more or less given to cannibalism.

Biting-Lice are small wingless insects, living as external parasites on the bodies of mammals and, more especially, on birds (whence the name of "bird-lice" is commonly given to

them). The strong mandibles are provided with sharp teeth, and are well adapted for cutting pieces off the young feathers and other epidermal products on which these creatures subsist. They are quite distinct from true blood-sucking lice, which have piercing mouth-parts and belong to the order Hemiptera (Bugs, &c.). Some five different species infest fowls, the commonest being the Pale Poultry-Louse (*Menopon pallidum*). Everyone must have noticed poultry taking "dust baths", the object of which is to get rid of some of these parasites.

The SNAKE-FLIES (see vol. i, p. 375), remarkable for the possession of a long neck, feed upon various small insects, and their heads are freely movable so as to enable them the more readily to seize their prey. The elongated larva is extremely active and possessed of an unbounded appetite. It lives in rotten wood, relentlessly hunting down other insects which have the same habitat.

SCORPION-FLIES (see vol. i, p. 375) constitute a small group in which both the adults and the spiny terrestrial larvæ are carnivorous. The elongated head is provided with strong, toothed mandibles. One of the European species (*Bittacus tipularius*) is particularly interesting, for it resembles a "daddy-long-legs", which no doubt allays the suspicions of the small flies upon which it feeds. Should one of these approach too near, it is liable to be captured by the hooked hind-legs of the apparently harmless insect, which meanwhile holds on to a plant by means of its two other pairs of elongated limbs.

ANT-LIONS.—One of the most notable insects in the whole order of Neuroptera is the Ant-Lion (*Myrmeleo formicarius*) (fig. 387), a common European form which has been the subject of observation for some two centuries. The chief interest attached to this creature centres in the backwardly-walking larva, to which stage the name "ant-lion" is properly applied. Its appearance is characteristic, and not calculated to inspire confidence in weaker insects, but this does not matter, as it is a case where the battle is to the "slim" rather than the swift. The powerful head is provided with enormously-developed curved mandibles, the stout thorax bears powerful legs, and the elongated abdomen is of oval shape. The ingenious method of hunting adopted in this case consists in the digging of a pitfall by the larva, which then lurks at the bottom of it. The insect navvy does not begin

excavating at the centre, but commences operations by constructing a groove to correspond with the margin of the proposed pit.

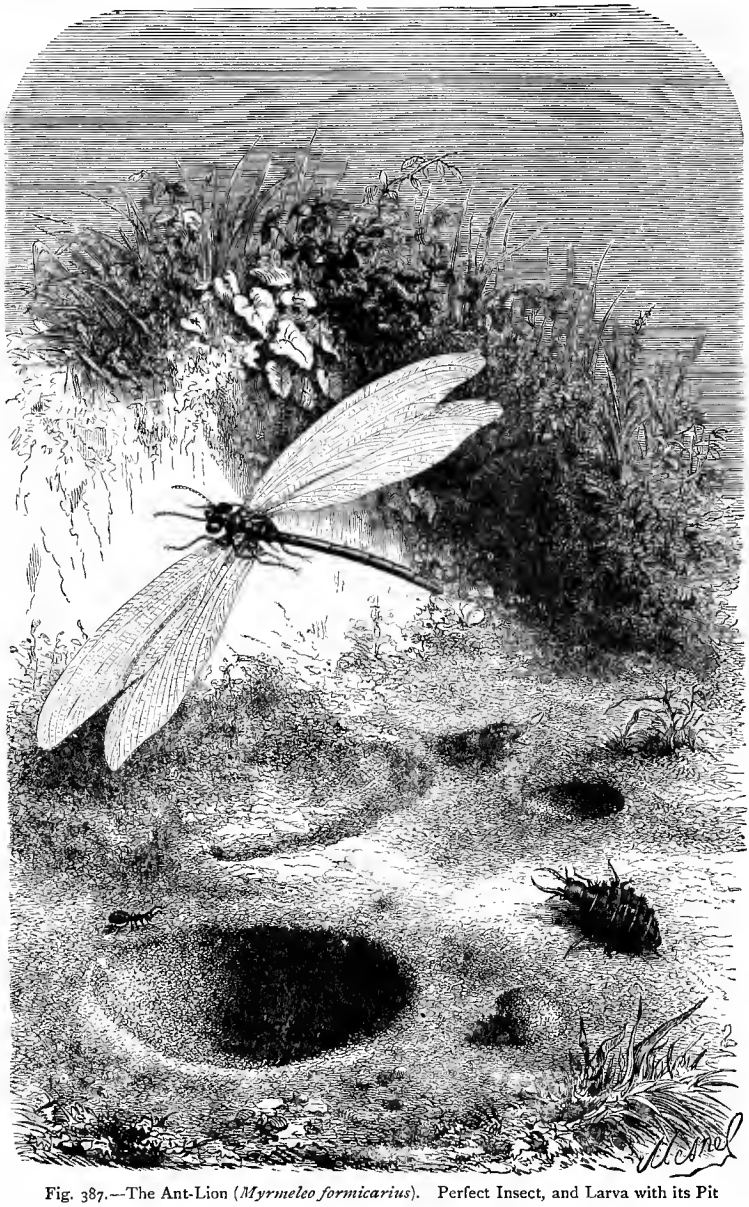


Fig. 387.—The Ant-Lion (*Myrmeleo formicarius*). Perfect Insect, and Larva with its Pit

Then it buries its abdomen in the sand, heaps some of the loose material on its head by means of the fore-legs, and pitches it off with a jerk to some little distance. The meaning of the

broad strong head is therefore at once apparent. After going all round in this fashion it moves inwards and works on a narrower circle, and so goes on till a conical pit is excavated, at the bottom of which it buries itself, the front part of the head only projecting. If now an unfortunate fly, or, still better, an ant, steps over the margin of the trap, it will begin to lose foothold, sliding gradually downwards, the descent being rendered still more easy by the ingenious ant-lion, which pitches sand on the prospective meal. Once seized by the aggressive-looking mandibles there is no chance of escape, for a special arrangement exists by which the juices of the prey can be sucked without any necessity for leaving go. The beginning of the food-tube is in the form of a muscular suction-pump to which a groove on the under side of each mandible leads, and in this groove the long and slender first maxilla of the same side works back and fore like a piston. After finishing its meal the bloodthirsty larva pitches the shrivelled remains of its victim to some distance, partly, perhaps, for sanitary reasons, and it may be to prevent other available wayfarers from taking alarm. It is interesting to note that certain cousins of the Ant-Lion, though similar in appearance, do not dig pit-falls. These, however, are active in their habits and progress in the usual direction, forward and not backward. It is supposed that they remain in ambush, hidden in dark corners, rushing out when a favourable opportunity offers.

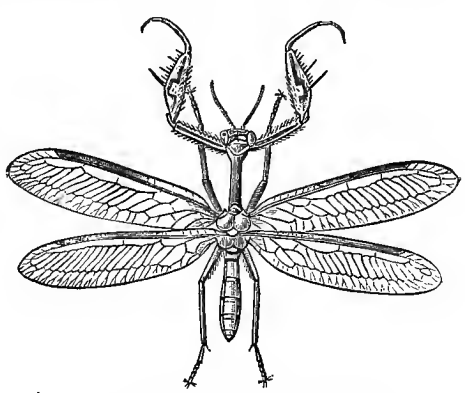


Fig. 388.—Mantis Net-Wing (*Mantispides*)

Mantis-like Net-Wings.—Equally interesting, though less familiar than the Ant-Lion, are the Mantis-like Net-Wings (*Mantispides*) (fig. 388), constituting a small group of which the species are mostly found in the hotter parts of the globe, though some are natives of South Europe. The great peculiarity of the adult insect consists in the structure of the strong fore-legs, which, as in the praying mantis, &c., among the Orthoptera, are attached close to the head and specialized into a very effective fly-trap. The middle section of each leg is studded with strong

spines, and the end-part of the limb can be folded down on these, much as the blade of a pocket-knife shuts down on the handle, so as to form a grasping structure well suited for seizing and holding active prey. The habits of the larva, which when first hatched is a slender creature much like some of the aquatic larvæ mentioned earlier, have been described for one of the European species (*Mantispes Styriaca*). At the time when it makes its appearance certain spiders (of the genus *Lycosa*) have laid their eggs, enclosed in little bags. One such bag is sought out by each larva, which bites a hole in it, creeps in, and patiently waits among the developing eggs till they hatch out into juicy little spiders, the sad fate of which is to be either at once devoured or else killed and reserved for future use. After a time the larva sheds its skin and becomes a sluggish grub-like creature, which, after making many hearty meals on the reserve spiders, passes through further stages, which result in the appearance of the adult form.

The Lace-wing Flies (*Hemerobiidæ* and *Chrysopidæ*) are small fragile insects of common occurrence in Britain, and interesting on account of the habits of their larvæ, which prey chiefly on aphides ("green fly"). The long slender mandibles may be described as "sucking spears", and are used for piercing the tender bodies of the prey, from which the juices are extracted much as in the case of the ant-lion. Some of these larvæ (*Hemerobius*, certain species of *Chrysopa*), which, by the bye, have appropriately been termed "aphis-lions", convert themselves into walking cemeteries by covering their spiny bodies with the shrivelled carcasses of their prey, a bold expedient for making them inconspicuous, others (some species of *Chrysopa*) use fragments of vegetable matter for the same purpose, while others again (most species of *Chrysopa*) resort to neither of these devices but prowl about unprotected. The Golden-eyed Flies (*Chrysopa*) (see vol. i, p. 378) are common British members of the group.

Dragon-Flies (see vol. i, p. 375).—In most of the neuropterous insects remaining to be mentioned here the larvæ are aquatic in habit. Among the most familiar and attractive of these are the Dragon-Flies, distinguished by their great powers of flight and very perfectly-developed sense organs, the compound eyes being of relatively enormous size. Like bats and swallows, they catch insects on the wing, and may often be seen hawking

for them in country lanes and above the surface of ponds. The legs of a Dragon-Fly are set on very far forwards, and this is believed to be related to one of their functions. Just as some bats use part of their flying membranes as a kind of sweep-net for securing insects on the wing, so would it appear that the dragon-fly's legs are forwardly directed during flight, acting as a sort of fly-trap, the efficiency of which is increased by the presence of numerous minute spines. Once entangled in this trap there is no hope of escape, for the aggressor brings his well-developed mouth-parts into play and conducts further operations, which result in the rejection of the wings and other inedible parts of the prey, and the retention of its more succulent portions for food. These acts are facilitated by the mobility of the dragon-fly's head, and the structure of its mouth-parts, which include a freely-movable upper lip, and a lower lip provided with two broad plates bounding on the under side the space within which the powerful mandibles and first maxillæ work from side to side. The rapacity of the aquatic larval form is even greater than that of the adult. It is a sluggish, by no means attractive-looking creature, thus described by Fred Smith (in *The Boyhood of a Naturalist*):—"And look here, here's the larva of a dragon-fly, a thing I can't help having a perfect horror of; it seems to me to be so truly hideous. It is like the nightmare of a horrible scorpion—I mean the Egyptian thing. Its legs, and glorious body, and wings that are to be, are now indescribably ugly, and as though made of dirty putty." Yet this same object is possessed of a most interesting and curious apparatus, by means of which it traps small crustaceans and any other animals of reasonable size that come near enough. This is the so-called "mask", which is thus named because when not in use it is folded up in front of the face, much in the same way as an old-fashioned carriage-step. It is in reality the much-elongated lower lip, and can be rapidly shot out at the prey, which is seized by a couple of movable spiny projections at its tip, and then drawn back to the well-armed mouth.

May-Flies and Stone-Flies.—The May-Flies (see vol. i, p. 375) and their allies (*Ephemerids*) are almost proverbial for the brevity of their existence in the adult condition, though there has been a good deal of exaggeration about this. It is doubtful whether they take any food at all, at any rate the

mouth-parts are in a very much reduced condition, and jaws may be altogether absent. The aquatic larvæ, on the other hand, have a relatively long term of existence. They differ largely in character in different species, and it is only the flattened forms that are exclusively carnivorous. Stone-Flies (*Perlidæ*) (see vol. i, p. 375) form a related group of insects in which the mouth-parts of the adult are feeble but the aquatic larvæ are carnivorous.

The Caddis-Flies (*Phryganeidæ*) (see vol. i, p. 375) are insects of moth-like appearance, and in the adult state are not predaceous. The aquatic larvæ, known as "caddis-worms", build cases for themselves from various materials, and as they are mainly vegetarians would not be mentioned here were it not for the peculiar and interesting habits of one group (*Hydropsychidæ*), in which the larvæ are carnivorous, at least in certain cases. They live in fixed dwellings made of sand or little pieces of stone fastened together with silk, and with this same material they construct snares in which small aquatic creatures are entangled. An account has been given of a Brazilian species in which the larvæ are found in the rapid parts of small streams, the houses of a number of these, as many as thirty, being placed side by side in a transverse row on top of a stone; there being also in some cases several parallel rows of them. The mouth of each habitation faces up-stream, and expands into a large funnel-shaped "verandah", over which a net of silk is spun. A North American species proceeds in a somewhat different manner, for it spins a wide-meshed net across the stems of water-plants, &c., in the neighbourhood of its dwelling, where it lies in wait for any prey that may chance to be snared. There is another allied group (*Rhyacophilides*), in which also the larvæ inhabit fixed cases, and one case is described where the front-legs are provided with strong forceps, evidently used for seizing prey.

STRAIGHT-WINGED INSECTS (Orthoptera)

These are insects with typical biting mouth-parts, which have been described in the case of the Cockroach (p. 102). The large majority of the species feed upon vegetable matter, or at most on a mixed diet, but a striking exception to this is afforded by the Soothsayers or Praying Insects (*Mantidæ*). These are

highly predaceous, feeding upon flies and other living insects, while some of the larger kinds are also said to attack small vertebrates. Most of the numerous species inhabit the hotter parts of the globe, throughout which they have a wide distribution; several are found in the Mediterranean countries of Europe, and one ranges as far north as Central France. The most remarkable feature in the structure of these insects is found in the first pair of legs, which are used for the purpose of catching and holding the prey. A similar arrangement has already been described for some of the Neuroptera (p. 114), and it essentially consists in a shifting forward of the front legs, which are extremely powerful, and so constructed that the end part can be folded back on to the middle section. As both these regions are provided with strong spines an efficient gripping organ is the result. The common European form, known as the Praying Mantis (*Mantis religiosa*) (fig. 389), is a comparatively simple example of this remarkable group. In colour green or brown, it harmonizes with the surroundings, and is thus rendered inconspicuous to its prey (aggressive general coloration), an end which is enhanced by its patient waiting attitude with the fore-legs stretched out as if in prayer, a position which has given rise to the popular names and originated many superstitions. Dr. Sharp says (in the *Cambridge Natural History*):—"Some of the older writers went so far as to say that a Mantis would indicate the road a child should take by stretching out one of its arms in the right direction". Speaking of the group generally the same authority adds:—"This appearance of innocence and quietness must have struck all who have seen these insects alive; nevertheless, it is of the most deceptive character, for the creature's activity consists of a series of wholesale massacres carried on day after day, the number of victims it sacrifices being enormous. The Mantis does not even spare its own kind; it is well known that the female not infrequently devours its own mate." To do justice to the habits of these interesting insects far more space would

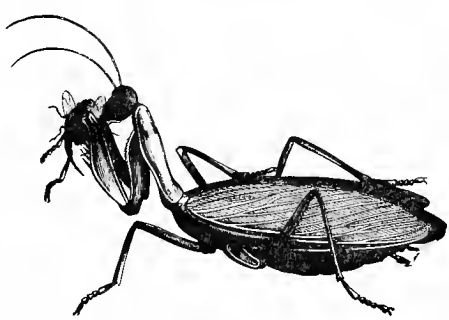


Fig. 389.—Praying Mantis (*Mantis religiosa*)

be required than is here available. Many of the tropical species are remarkable for their curious form and coloration, by which a close resemblance to foliage or flowers is brought about. Nor do all of them wait till prey comes within reach: a species inhabiting New Zealand (though probably introduced from Australia) has been described which is in the habit of stalking its victims till near enough to secure them by a sudden rush. Annandale has recently given a very interesting account of a pink Mantis found in Siam, which will serve as a final illustration. This creature is in the habit of stationing itself on the look-out for prey in the midst of groups of pink flowers something like rhododendrons in appearance. The limbs and front part of the body are of the same tint, and so is the under side of the abdomen, which is bent up over the back so as to be in full view. As, however, the insect is too large to be mistaken for part of a single flower, there is a green band which runs across the upper side of the thorax and divides the pink colour into two sections which harmonize with two different blossoms. It may also be added that there is a small black patch at the tip of the abdomen upon which minute flies are in the habit of perching. Being too insignificant to be worth capturing, the Mantis leaves these alone, and their presence adds to the illusion. This, however, is not all, for when the group of flowers withers the Mantis migrates to another, turning down the abdomen so as to display the upper surface, which is marked with brown lines so as to suggest a withering flower. And further, when in this posture, the insect looks very much like an orchis blossom, for the striped abdomen simulates the broad lower petal (labellum), while the limbs, which are broadened out, together with the front part of the body, represent the rest of the orchis. This is a marvellous instance of aggressive special coloration and form, whereby some predaceous animals resemble definite objects so closely that their prey is prevented from taking alarm.

Passing by the Wingless Insects (Aptera), which have little-developed mouth-parts, and for the most part are believed to live on disintegrating vegetable matter, we come to carnivorous insects with sucking mouth-parts.

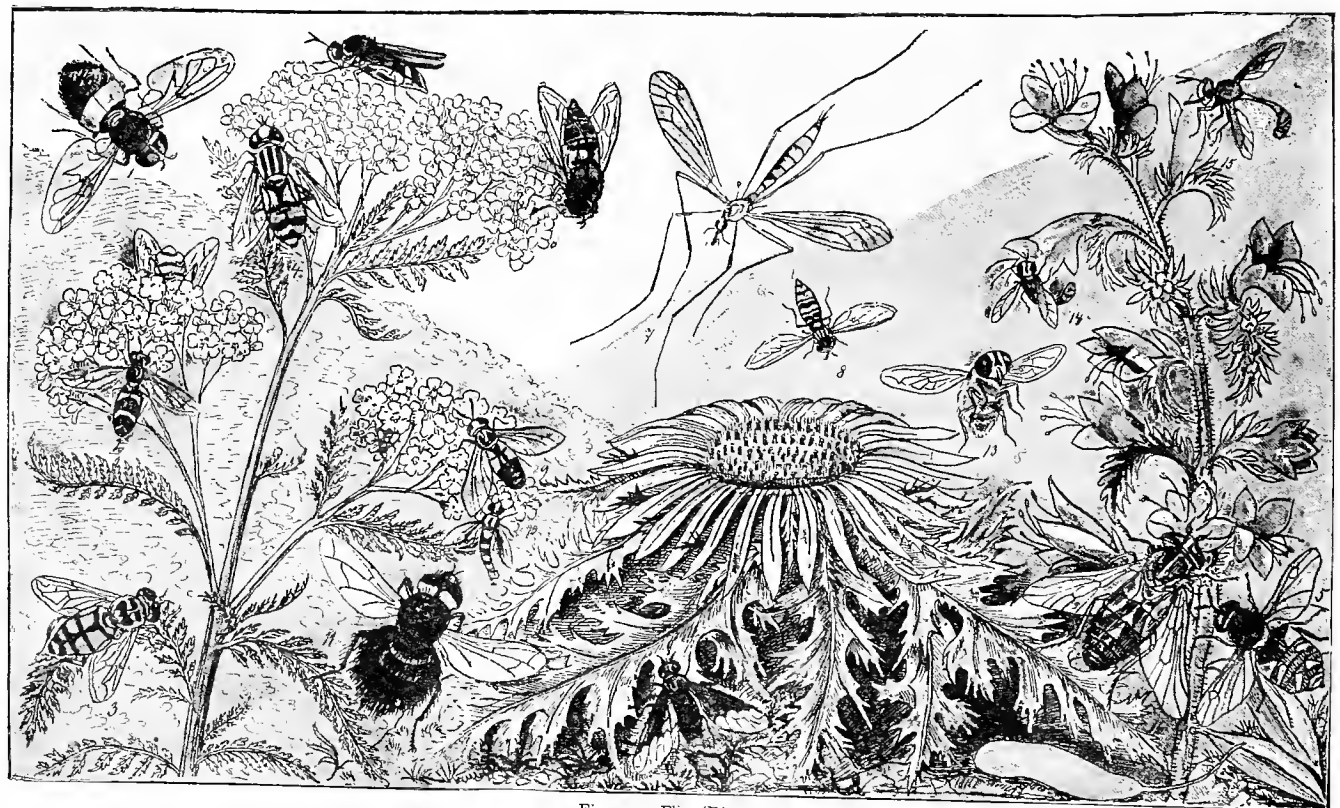


Fig. 390.—Flies (Diptera)

1, Humble-Bee Fly (*Volucella pellucens*); 2, Bow-Fly (*Chrysotoxum bicinctum*); 3, 4, and 13, Meadow-Flies (*Helophilus*); 5, Soldier-Fly (*Stratiomys chameleon*); 6, Drone-Fly (*Eristalis tenax*); 7, Crane-Fly (*Tipula oleracea*); 8, Hover-Fly (*Syrphus balteatus*); 9, Gold-eyed Fly (*Chrysops cæcutiens*); 10, Hissing-Fly (*Syrittus pipiens*); 11, Great Spring-Fly (*Echinomyia grossa*); 12, Bee-Fly (*Anthrax morio*); 14, Bladder-headed Fly (*Myopa ferruginea*); 15, Thick-headed Fly (*Conops flavipes*); 16, Gad-Fly (*Tabanus bovis*); 17, Larva of Drone-Fly.

MOTHS AND BUTTERFLIES (LEPIDOPTERA)

This is essentially a vegetarian order, and, as such, will be described later on. The caterpillars of some moths, however, infest furs, which they gnaw with their powerful mandibles, and there are some adult members of the group, such as the Purple Emperor Moth, which are fond of carrion, drawing up its decomposing juices through the tubular proboscis formed by the elongation of the first maxillæ.

FLIES (DIPTERA) (fig. 390)

Many of the vast horde of Two-winged Flies which make up this order are either predaceous, or else subsist on animal matter. Most persons are under the impression that the common House-Fly (*Musca domestica*) is able to bite at certain seasons of the year, an erroneous idea partly due to the fact that a similar-looking insect exists which has piercing mouth-parts. This is the Stable-Fly (*Stomoxys calcitrans*) (compare fig. 392). The

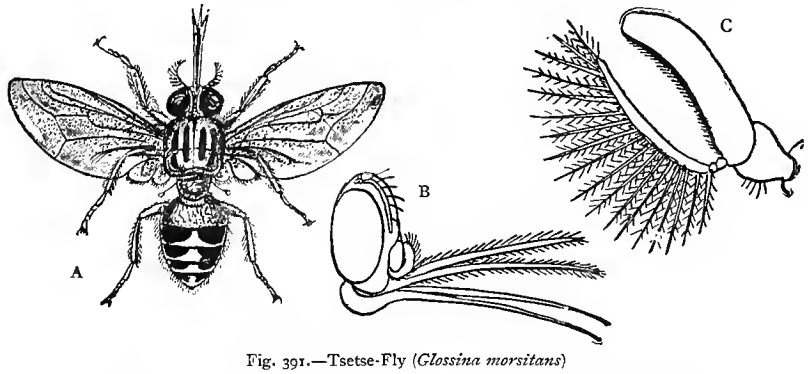


Fig. 391.—Tsetse-Fly (*Glossina morsitans*)
A, Adult fly (enlarged); B, Piercing mouth-parts, and C, Antenna (greatly enlarged).

mouth-parts of the formidable Tsetse-Fly (*Glossina morsitans*) (fig. 391) of Tropical Africa are of similar kind.

GAD-FLIES.—It is a common thing for the blood-sucking habit to be confined to the female insects, and a good example is furnished by the Gad-Flies, of which the Ox-Fly or Great Horse-Fly (*Tabanus bovinus*) is a terrible pest to horses and cattle. A much commoner British insect, belonging to the same family, is the familiar Clegg (*Hæmatopota pluvialis*), abundant in woods, and of particularly slow flight. Most of us have experienced the vicious stab this undesirable creature inflicts, and only an un-

usually benevolent person could resist the chance of immolating the aggressor, a particularly easy matter as it happens. Bot-Flies make up a family with reduced mouth-parts, and, though not blood-suckers, are more dangerous to horses and stock than Gad-Flies and the like, for they lay their eggs upon domestic animals, upon or inside which the larvæ, when they hatch out, become parasitic. Details will be given when the question of parasitism is discussed.

Gnats and Midges.—Few animals cause more annoyance and discomfort than the Gnats, Mosquitoes, Sand-Midges, and, to a less extent, true Midges, which abound in all parts of the the world, and have been made notorious by the lurid descriptions of innumerable travellers. Mosquitoes and Gnats (*Culicidæ*) are one and the same thing; a familiar British species is the Common Gnat (*Culex pipiens*), which possesses typical piercing mouth-parts (fig. 392). The labrum is a long, pointed structure, with its grooved under side forming a canal along which blood is conducted to the mouth. Both mandibles and first maxillæ are lengthened out into piercing bristles, by which a wound can be inflicted, and which are enclosed in a sort of sheath formed by a modification of the labium. It should further be noted that a long, pointed tongue (hypopharynx), upon the end of which the ducts of the salivary glands open, is enclosed in this sheath, from the back part of which it grows out. Sand-Midges (*Simuliidæ*), poorly represented in Britain, are most abundant in the tropics, and though much smaller than Gnats, are even more noxious, their bite being particularly virulent. The name of "Sand-Fly" is commonly given to them. Midges (*Chironomidæ*) are minute insects, for the most part not adapted for blood-sucking, though to this there are exceptions, as in the case of the common Black Midge (species of *Ceratopogon*), which is one of our summer pests in the country. In all these cases it is the female only that feasts on blood, and her mouth-parts are therefore adapted for piercing and sucking, conforming more or less closely to the type described for the Gnat.

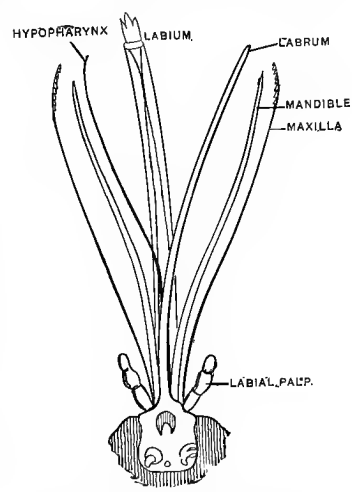


Fig. 392.—Mouth parts of a Female Gn (*Culex pipens*), greatly magnified

The Forest-Flies (*Hippoboscidæ*) are curious Diptera, parasitic on the bodies of various warm-blooded animals, and presenting us with a series of species showing the gradual degeneration and disappearance of the wings. This is interesting because it helps to throw light on those unpleasant and familiar creatures called Fleas, which are very likely to be looked upon as wingless Diptera, of which the remote ancestors possessed wings. The best-known species is the ubiquitous Common Flea (*Pulex irritans*) (fig. 393), but Mammals and Birds are infested by numerous other kinds, it being a common error to suppose there is but one sort of these creatures. The piercing and sucking mouth-parts differ in some respects from those of Gnats, &c. The long, pointed labrum is grooved on its under side, and is closely applied to the hard, piercing mandibles, while a sheath is formed by the two pairs of maxillæ.

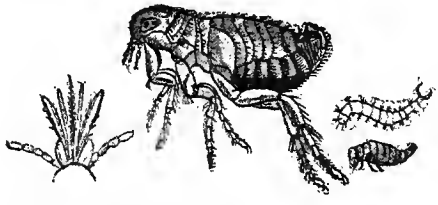


Fig. 393.—The Common Flea (*Pulex irritans*)

On the left are the piercing mouth-parts. On the right, larva (above) and pupa (below). Enlarged to various scales.

The Fringe-winged Insects (Thysanoptera) include minute forms which feed on plants, and therefore do not require notice here.

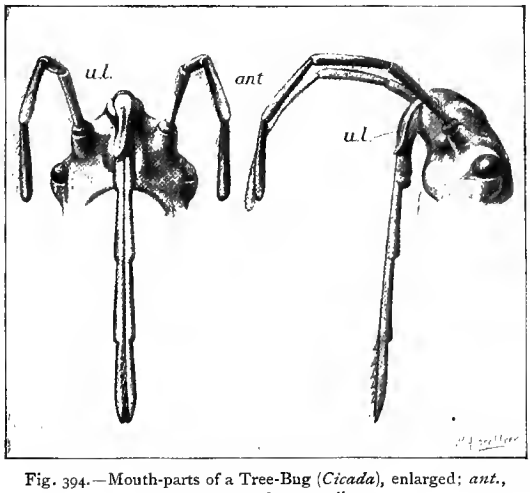


Fig. 394.—Mouth-parts of a Tree-Bug (*Cicada*), enlarged; *ant.*, antennæ; *u.l.*, upper lip.

BUGS (Hemiptera)

In this, the last order of insects, are included a great variety of forms, such as bugs, aphides, true lice, &c., most of which are terrestrial, though a fair number are aquatic. The food may consist of the juices of animals or the sap of plants, and in either case the mouth-parts are adapted for piercing and sucking, though constructed on a somewhat different type from that described for the Diptera. Examination of one of these creatures (fig. 394) reveals the presence of a piercing beak, which consists of

a tubular sheath, enclosing four piercing, and it may be barbed, lancets, representing the mandibles and first maxillæ. Each of the former is doubly grooved on its inner side, so that, when opposed to its fellow, two channels are formed, along one of which the juices of the food are conducted to the mouth, while the other serves for the transmission of saliva. A gap left in the front of the tubular sheath is filled up by the pointed labrum.

Land-Bugs.—Most of the terrestrial Hemiptera are vegetarian in habit, but to this there are some notable exceptions. For ex-

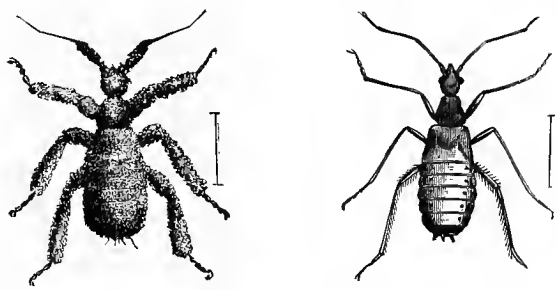


Fig. 395.—Larva of *Reduvius personatus*. Actual size shown by line.

ample, a large British species, for which there is no common name, but which is known scientifically as *Reduvius personatus* (fig. 395), preys upon other insects, including, it is said, the objectionable bed-bug. The front legs are adapted for seizing prey—a peculiarity of which examples have been given among other insects—and the predaceous larva of this insect is remarkable for its disreputable appearance, being covered with dust and rubbish in a remarkable way, an arrangement which probably shields it from observation. The evil-smelling Bed-Bug (*Acanthia lectularia*), of which the less said the better, is a wingless species.

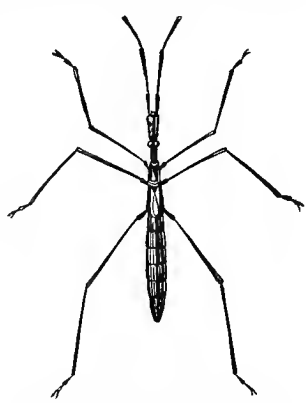


Fig. 396.—A Pond-Skater (*Gerris paludum*), enlarged

Water-Bugs.—The habits of some of the aquatic bugs (fig. 396) are very interesting. Among them, the Pond-Skaters, slender insects which, so to speak, skate on the surface of the water, at once attract attention. The Needle-Bug (*Limnobates stagnorum*)

is recognized by its extremely slender body and leisurely gait, while the Common Skaters (*Gerris paludum*) are somewhat broader, and very rapid in their movements, pouncing swiftly upon flies and other insects, which they seize with their fore-legs. The Water-Boatmen (*Notonecta glauca* and others) are comparatively broad aquatic bugs of predaceous habit, which swim on their backs, using the long hind-legs as sculls. More sluggish and of forbidding appearance are the Water-Scorpions and Long Water-Bugs. The common Water-Scorpion (*Nepa cinerea*) (fig. 385) is a sombre-looking flattened creature with large grasping front legs, the appearance of which suggests the popular name. There is also a curious bristle-like tail, which has to do with breathing, and will be described elsewhere. The Long Water-Bug (*Ranatra linearis*), to use the words of Staveley (in *British Insects*), "resembles the Nepa in having a small head, two long tails, and extended prehensile fore-legs, but here all family likeness ends, for this most curious-looking creature is but a series of thickish *lines* (as ts name imports). A long linear body with two long thin tails, and four long thin legs, are all we can see except a pair of forceps [*i.e.* the fore-legs], which would be long and thin too if they were not so crooked. The creature looks cruel and hungry, but where it stows all the prey for which it is so greedy is a problem to be solved. A less aldermanic figure can scarcely be conceived. . . ."

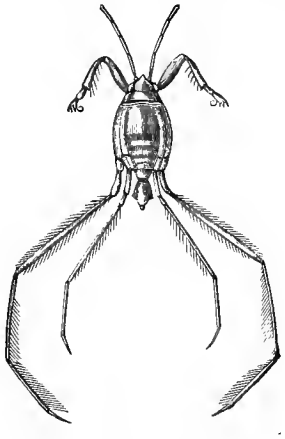


Fig. 397.—A Marine Bug (*Halobates*)

A marine bug (*Halobates*) (fig. 397) is particularly interesting as being one of the very few insects which inhabit the open sea. It has been found skating on the surface, far out of sight of land.

True Lice are wingless blood-sucking creatures, shown by the nature of their mouth-parts to be degraded forms of the Hemiptera. The tips of their legs are hooked, so as to give a firm hold on the exterior of their host.

CHAPTER X

THE FOOD OF ANIMALS—CARNIVOROUS ARACHNIDA AND MYRIAPODA—PERIPATUS

SPIDER-LIKE ANIMALS (ARACHNIDA)

The second class of air-breathing Arthropods to be considered is that of the ARACHNIDA, including Scorpions, Whip-Scorpions, Spiders, False Spiders, False Scorpions, Harvestmen, Mites, and Ticks.

SCORPIONS (SCORPIONIDÆ) (see vol. i, p. 385)

These unpleasant creatures are found in nearly all the hotter parts of the globe, and all of them capture living prey of various nature. Scorpions are mostly nocturnal, and this may partly account for the fact that they perceive the presence of their quarry by touch rather than sight, and the large pincers are of importance in this respect, playing the part of tactile organs as well as of weapons. Many Scorpions find a refuge and lurking-place combined underneath stones or in convenient crannies, others make excavations in earth or sand for the same purposes. The large pincers (*pedipalpi*) are used for seizing prey, in which also the smaller nippers (*cheliceræ*) in front of them may help, the narrow tail is then bent forward with great rapidity, and the sting in which it ends brought into use. Two poison-glands are lodged within the broad base of the sting, and open upon its tip. The mouth is extremely small, and the front part of the food-tube is specialized into a suction-pump by which the juices of the prey are extracted.

WHIP-SCORPIONS (PEDIPALPI) (see vol. i, p. 389)

The curious little WHIP-SCORPIONS (*Pedipalpi*), widely distributed in the tropical and hot parts of both New and Old Worlds, are predaceous forms, unprovided with the poisoned sting of their larger namesakes. The hind end of the body may be possessed of

a thread-like appendage, looking like an attenuated representative of the Scorpion's tail, or, in some members of the group, there is nothing but a little knob to represent the tail. The tailed species have both small and large pincers, as in the ordinary Scorpions, but the latter are not so well developed. Those appendages of the tailless forms which are equivalent to the large pincers are of considerable size, but do not end in nippers, having instead a spiny end-joint, which can be bent back on the equally spiny joint by which it is borne to form an efficient grasping organ. The arrangement may be compared to that found in the fore-legs of the Praying Mantis (p. 117), and it is a common device in many groups of animals which require a simple holding-apparatus. It has already been pointed out that in Insects the slender feelers or antennæ are of great use in giving the animal a means of exploring to the front, and that in Scorpions the large pincers are used for this purpose. The same end is attained in the Whip-Scorpions by diverting the front pair of legs from their usual locomotor function, while at the same time they are modified into forwardly-directed organs of touch. The specialization has not gone far in the tailed members of this group, but in the tailless ones it is extreme. We have here an excellent example of the principle of "change of function", of which instances have already been given in other connections, and the comparison of Insect, Scorpion, and Whip-Scorpion, just instituted, also illustrates another important biological principle, that of *analogy*, which lays it down as an axiom that organs performing equivalent functions are not necessarily equivalent as regards their origin and structure.

SPIDERS (ARANEIDÆ)

Spiders (*Araneidæ*) are highly rapacious forms which constitute a large and exceedingly interesting order, distinguished from the other groups of Arachnida by many peculiarities. There are no large grasping organs as in the forms so far described, the appendages corresponding to them being short feelers with bases that are used as jaws. Poison-glands are present, however, but these, instead of being lodged in a posterior sting as in a scorpion, are contained within the first jaws (*cheliceræ*), upon the tips of which they open. These jaws are not in the form of nippers, but present the arrangement just described for the seizing organs of whip-scorpions, the claw-like end-joint moving

upon the toothed joint which carries it, as the blade of a penknife does upon its handle. Spider poison may be of an extremely virulent kind, as will be seen by the following extract from Semon (quoted from *In the Australian Bush*):—"More poisonous than all the other insects of Australia [the word "insect" is here used in a popular way] . . . is a little black spider with a back of vivid red, *Latrodectus scelio.* This conspicuous spider seems to be everywhere. Though chiefly nocturnal in its habits, it also appears in daytime, imposing on you by a certain calm impudence. It takes no trouble whatever to escape or to hide, but, relying on its fatal poison, seems rather to warn you by its vivid colour than to elude your vision by a more modest mien. The bite of this spider is terribly painful, and in its wake we often find paralytic symptoms in the wounded member, its neighbouring organs, or even the entire body. It is said that grown-up people are sometimes killed by it, and surely this is the most poisonous spider in the world, and the most dangerous arthropod in existence." Undoubtedly, however the most interesting and characteristic feature about spiders is found in the spinning organs which they possess. These are in the form of silk-glands, which open by innumerable pores upon the surface of four little teat-like projections placed on the under side of the abdomen (fig. 398).

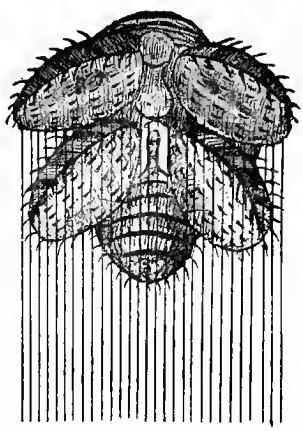


Fig. 398.—Spinnerets of Spider (greatly enlarged)

Web-Spinners.—The best-known kinds of spiders construct webs for snaring prey, the most perfect and regular of these contrivances being the work of the numerous species included under the term "orb spinners", of which the common Cross or Garden Spider (*Epeira diadema*) (see vol. i, p. 391) may be taken as a good type. Such a web consists of radiating strands which form a supporting basis, and of a sticky thread which winds round in a spiral way from centre to circumference, and holds fast any unfortunate insect that happens to fly against the snare, which is possessed of a considerable amount of elasticity, so as not to be readily broken. The spider lies in wait for prey in the neighbourhood of the web, concealed in some cranny or under a leaf,

and a line running from its hiding-place to the snare gives notice by its vibrations of the capture of prey. Should a comparatively large insect be caught, the spider envelops it in a winding-sheet of silk, and either kills it at once, or, if already sated, leaves it for a future meal. The construction of such an elaborate snare as that of the Garden Spider requires no little ingenuity and care. To begin with, the apparently simple threads are in reality complex, being composed, like a rope, of a number of strands, in this case of extreme tenuity. The reason for such complexity is not far to seek. A thread composed of numerous strands is stronger than one of the same bulk would be if made in one piece only; and, further, the viscid material of which the web is composed obviously hardens more quickly when exposed to the air in extremely slender threads than would otherwise be the case. The spinnerets of this particular spider are simply riddled like a sieve by the minute openings of silk-glands, there being, at a moderate computation, some 700 pores in all. The material secreted by the silk-glands is not all of the same kind, for some is destined to be worked up into the non-viscid radiating threads, while others supply the material for the sticky spiral one. Nor is the breadth of the component filaments the same in all cases. The feet of the spider are armed with several curved and toothed claws, and it is more especially those of the hind-legs which are used to work up the raw material into complex lines. The claws also enable the animal to easily climb about its web or travel along the connecting line running from its hiding-place. Staveley (in *British Spiders*) thus describes the way in which the spider constructs her regular web[1]:—"The process by which the net of the garden spider is constructed is well worth observing. The first step is to extend a horizontal cord between two neighbouring points. This is done with the aid of the wind, the spider exposing the spinnerets to a current of air whilst emitting the fluid silk. A thread is thus, as it were, drawn from the spider by the power of the wind, and, coming into contact with some neighbouring object, adheres by its own natural stickiness. This is the commencement of the framework, which is completed by lines placed according to circumstances, some by the spider dropping and swinging from point to point, attaching a thread wherever she touches, and others, as in the case of the first, by means of the wind. The framework

[1] "She" has been substituted for "he" throughout the quotation.

completed, the spider goes to the middle of the upper horizontal line, touches it with the spinnerets, so attaching the beginning of a thread to it, and drops perpendicularly on to the line forming the lowest side of the framework, where she fastens the second end of the thread. She then climbs up this till she reaches the middle (which is to be the middle of the web), and here she fixes the beginning of another thread. She now ascends the perpendicular thread, drawing out the new one as she goes, till she reaches the upper line, along which she walks to the point at which she sees fit to attach this *radius* of her web. She now returns to the centre, and repeats the process, each time walking up the last-formed radius as she draws a new one, till the whole area of the web is filled with radiating lines.

"The next process is to connect the radii by a spiral line, so forming the *meshes* of the net. The spider places herself in the

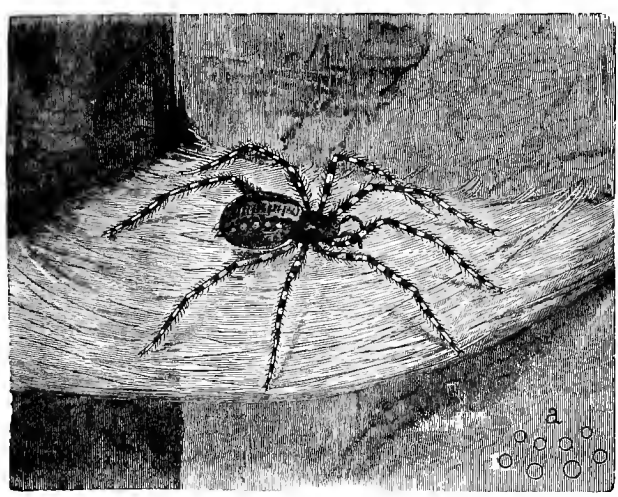


Fig. 399.—A House-Spider (*Tegenaria*) in its Web; arrangement of eyes shown at *a*.

centre of the web, and attaching a thread there, turns round, drawing a line from the spinnerets, which she applies to ray after ray, fastening it with the aid of her hind-legs. She proceeds farther and farther from the centre until a spiral line has been described from thence to the circumference of the web, where she affixes another thread, and, reversing the operation, draws a second spiral line from the circumference to the centre." The Garden Spider and our other native orb-spinners are all of comparatively small size, but there are some large tropical species

which construct snares of corresponding dimensions, and stated to be strong enough to capture small birds.

A less-complex and differently-placed snare is constructed by the common Field Spider (*Agalena labyrinthica*), of which the dense white webs are often to be observed on heaths and commons, stretched horizontally among such plants as furze. These are often extremely abundant, and seen when covered with dew in the early morning are exceedingly conspicuous. A dwelling for the spider in the form of a silken tube hangs down vertically from some part of the web, and at the mouth of this the occupant remains on the look-out for prey. The House-Spiders (species of *Tegenaria*) (fig. 399) are members of the same family, and their dirty-looking snares, familiarly called "cobwebs", are connected at one corner with the den of the spider, in this case a horizontally-placed tube open at both ends and slung from a support by means of a number of strong threads.

HUNTERS.—The above will perhaps serve to give an idea of the way in which snare-spinning spiders secure their prey, and we may now turn our attention to some of the Hunting Spiders, which secure their victims either by craft or speed, or it may be by a combination of the two. Here are included the largest and most repulsive-looking members of the order, the Bird-catching Spiders of tropical and hot regions. A well-known South American species (*Mygale avicularia*) (see fig. 384) has been described by Bates and other naturalists as of nocturnal habit, preying on all sorts of animals from birds downwards. As these creatures do not spin webs for the capture of prey, there is not the same need for well-developed claws, and we accordingly find that these are small, while tufts of hair are present, which are used as climbing pads, enabling the creature to scale smooth and steep surfaces.

The Wolf-Spiders (fig. 400) include smaller species which run with great rapidity, and are thus enabled to overtake their prey. A number of small British spiders (species of *Lycosa*, &c.) belong to this group, but a much more notable species is the Tarantula (*Lycosa tarantula*) of South Europe, a larger kind, reputed to have a most virulent bite, only to be cured by extremely rapid dancing to appropriate music. This is, indeed, the origin of the dance known as the tarantella. One of our smaller native kinds of Wolf-Spider (*Lycosa piratica*) haunts the margins of ponds, and

is able to run on the surface of the water in pursuit of prey, or even to dive, this being rendered possible by the entanglement of air-bubbles among the numerous hairs with which the body is covered. Another member of the same family, the Raft-Spider (*Dolomedes fimbriatus*), possesses the same powers as the pre-



Fig. 400.—Hunting Spiders (*Salticus scenicus*)

ceding, but by constructing for itself a raft of leaves is able to make a more extended use of them. There are other families of spiders the members of which are thorough-going aquatic forms, a familiar British example being the Water-Spider (*Argyroneta aquatica*), of which more will be said in another connection.

The last group to be here mentioned is that of the Jumping Spiders (fig. 400), which patiently stalk their prey and ultimately secure it by a final rapid jump. A very common little British form, the Harlequin Spider (*Salticus scenicus*), in which even the larger female is only about a quarter of an inch long, is distinguished by conspicuous striped markings.

FALSE SPIDERS (SOLPUGIDÆ) (see vol. i, p. 388)

These arachnids are rapacious forms superficially resembling large spiders, and have a wide distribution through the warmer parts of both New and Old Worlds, ranging in the latter into the Mediterranean countries of Europe and the south-east of Russia. At first sight they seem to have ten pairs of legs, but the first pair of these apparent legs are in reality the appendages corresponding to the great claws of the Scorpions, serving in this case as feelers, a function which is also shared by the first pair of legs proper, somewhat as in Whip-Scorpions. The jaws are of large size, and the food chiefly consists of insects, though they also attack other arachnids, even Scorpions. Desert regions are especially affected by them.

FALSE SCORPIONS (PSEUDOSCORPIONIDÆ) (see vol. i, p. 389)

These minute creatures owe their superficial resemblance to Scorpions chiefly to the fact that the first two pairs of appendages are constructed on the same plan. They do not, however, possess tails, and differ in many other ways from their namesakes. False Scorpions lurk under bark and in all sorts of crannies where they are likely to meet with their food, which consists of mites and small wingless insects. They are often to be found in old books, neglected plant collections, and the like.

HARVESTMEN (PHALANGIDÆ) (see vol. i, p. 390)

The members of this group, with which we are familiar in this country, look something like spiders with very long thin legs, but are in reality as unlike spiders in structure as false scorpions are unlike true ones. The first pair of jaws are strong nippers suited for seizing insects or other small creatures, while the second pair of appendages are feelers.

MITES AND TICKS (ACARINA)

Those members of this specialized group which live upon animal matter are parasitic in the most interesting cases, and consideration of them may be postponed till parasitism is dealt with.

CENTIPEDES AND MILLIPEDES (MYRIAPODA)

Centipedes, Millipedes, and their allies together constitute the third class of air-breathing Arthropoda, to which the name of Myriapoda has been applied on account of the large number of legs usually present. Millipedes are of vegetarian habit, and will be considered elsewhere.

CENTIPEDES (SYNGNATHA or CHILOPODA)

Centipedes are highly predaceous animals, feeding upon insects and other invertebrates. One of the commonest native species, the Thirty-foot (*Lithobius forficatus*) (see vol. i, p. 394), is an active, chestnut-coloured thirty-legged animal, common under stones and in garden earth. The head bears two groups of simple eyes and a pair of long feelers, which no doubt—the latter especially—aid in the pursuit of prey. The mouth-parts are of biting

nature, and in some respects conform to the description already given for insects of similar habit (p. 107). There are three pairs of jaws, of which the first are powerful mandibles, provided with strong tooth-like projections where they work against one another. Then follow first maxillæ, each of which has two branches, and these are succeeded by a pair of second maxillæ united together in the middle line, and looking very much like transformed legs, which no doubt they are. But a Centipede is better off in the jaw line than an Insect, for outside the second maxillæ come still another pair of metamorphosed legs, closely united together in the middle, while each of them bears a jointed curved *poison-claw*, near the tip of which a poison-gland opens. The poisonous Centipedes of tropical countries agree essentially in structure with the species just described, but are very much larger, and possess more numerous legs. Their bite is dreaded by human beings, and is stated to be sometimes fatal. Nor must it be supposed that the food of such creatures is restricted to invertebrates, for they are known to attack small vertebrates of various kinds.

Among the families of these creatures represented in Britain is one including the Earth Centipedes (*Geophilidæ*) (see vol. i, p. 394), long slender forms which live underground and prey upon earth-worms. Their narrow bodies are eminently adapted for burrowing through the soil, and also for twining round and round their wriggling prey, besides which it may be observed that eyes are altogether absent, clearly as a result of subterranean life. Predaceous Myriapods, however, may run to the opposite extreme, for in the Shield-bearing Centipedes (species of *Scutigera*) (fig. 401), so named from the presence of a single series of shield-shaped scales along the upper surface, we have forms which, instead of shunning the light, hunt their prey in open view. Possessed of very long antennæ and well-developed compound eyes, they are able readily to detect the presence of suitable victims, and their spider-like legs are swift in pursuit. Concerning these creatures, which by the bye are placed in a special order of Myriapods (SCHIZOTARSIA), Sinclair writes as follows (in *The Cambridge Natural History*):—"Some years ago

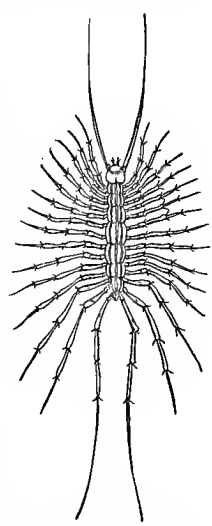


Fig. 401.—Shield-bearing Centipede (*Scutigera*)

I was in Malta, and I used to go and watch them on the slopes outside Valetta, where they were to be found in great numbers. They used to come out from beneath great stones and run about rapidly on the ground or on the stones and rubbish with which the ground was covered, now and again making a dart at some small insect which tempted them, and seemingly not minding the blazing sun at all."

PRIMITIVE TRACHEATES (PROTOTRACHEATA)

The last and lowest class, Prototracheata, of the air-breathing Arthropods, has been instituted for the reception of a single genus[1] known by the name of Peripatus (see vol. i, pp. 399 and 400), of which species are distributed all round the world in tropical regions. Found in rotten wood and in crevices among stones, it looks not unlike a caterpillar with numerous pairs of clumsy-looking legs, each ending in a pair of claws. Though eyes are present, they probably do little more than enable the animal to avoid the light, and this slowly-moving creature seems to detect its prey, consisting of flies and other small animals, by means of its mobile feelers. Observations made on the New Zealand species show pretty clearly that sluggishness in movement is made up for by well-developed *slime-glands*, opening on a pair of short modified limbs (oral papillæ) near the mouth. From these it is able rapidly to eject a sticky fluid to a distance of a foot, an arrangement which is probably as efficient as the sticky tongue of an ant-eater, a woodpecker, or a chameleon. Once secured, the prey is dealt with by a pair of jaws, working from side to side in the usual arthropod manner, and each provided with a couple of sharp blades. It is a striking character of Arthropods generally that some of the limbs near the mouth should have assumed a chewing function, and here we have the arrangement in its simplest form, as but one pair of limbs is specialized into jaws.

[1] This has recently been broken up into other genera, but the common usage is convenient in a popular work.

CHAPTER XI

THE FOOD OF ANIMALS—CARNIVOROUS CRUSTACEA AND KING-CRABS

Air-breathing Arthropods having been now briefly reviewed, so far as carnivorous species are concerned, we now turn to aquatic Arthropods, breathing the air dissolved in water by means of more or less complicated *gills*, except in the case of some very small creatures which are able to perform this function by the general surface of the body. Amongst such forms by far the largest and most important class is that of the CRUSTACEA, including lobsters, crayfish, shrimps, prawns, crabs, and a host of other forms. A very large number of these are carnivorous, some being adapted for the capture of living prey, while others feed on carrion. Indeed it may be said of the group that to a large extent they act as scavengers. The members of the KING-CRAB class (*Xiphosura*) are also carnivorous.

CRUSTACEANS (CRUSTACEA)

It will be convenient first of all to consider the Higher Crustacea (Malacostraca), and afterwards to turn our attention to Lower Crustacea (Entomostraca).

HIGHER CRUSTACEA (MALACOSTRACA)—STALK-EYED FORMS (THORACOSTRACA)

The most familiar members of this subdivision belong to the DECAPODA, or Ten-legged Crustacea, of which the Lobster (*Homarus vulgaris*) has already been described as a type (vol. i, pp. 402–409). In such a form we can at once detect characters having relation to a predaceous habit, among which may be more particularly mentioned the huge pincers and the well-developed sense-organs, including more especially stalked com-

pound eyes and very long feelers (antennæ), which are able to explore a considerable area in the neighbourhood of their owner. And, as might be expected in a scavenging animal, organs of smell are well developed, being here in the form of tufts of delicate flattened hairs attached to the small feelers (antennules), which are placed in front of the large ones. It is no doubt largely by the sense of smell that lobsters (and crabs) find their

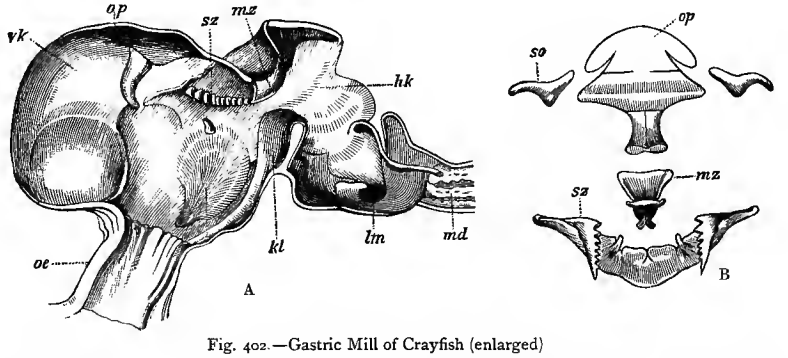


Fig. 402.—Gastric Mill of Crayfish (enlarged)

A, Stomach in section. B, Parts of mill dissected out. *oe*, Gullet; *vk*, chewing region; *hk*, straining region; *kl*, fold between two parts of stomach; *md*, intestine; *op*, front bar of mill; *so*, side-bar; *sz*, bar carrying lateral tooth; *mz*, bar carrying middle tooth.

way to the traps baited with offal that are set for them. These animals possess efficient means for dealing with the food when once this is secured, for there are no less than six pairs of jaws constituted by the specialization of limbs, and working from side to side in the usual arthropod manner. Nor is this all, for the Lobster, like many other crustaceans, is provided with a complicated chewing apparatus in the stomach, known as the gastric mill (see fig. 402), and consisting of a framework of hard parts which bear three tooth-like projections, one long ridged tooth on either side, and a forked median tooth borne on a downwardly-directed bar. By means of appropriate muscles attached to the framework the three teeth can be brought together so as to effectually crush anything that happens to be between them. The hinder part of the stomach is specialized into a straining apparatus, numerous stiff bristles projecting into its cavity and interlacing with one another so as to constitute a very efficient sieve. Such parts of the food as cannot be reduced to fine particles by the action of the jaws and gastric mill are ejected to the exterior through the mouth. The internal chewing arrangements remind one strongly

in function, though not in the details of structure, of the gizzards of birds, crocodiles, some insects, and certain molluscs.

The Common Prawn (*Palæmon serratus*) is not unlike a minute lobster in structure, and naturally hunts down smaller prey. The Common Shrimp (*Crangon vulgaris*) is still smaller than the prawn, to which it has a general resemblance, differing, however, in many details of structure. There are no pincers, properly so-called, but the corresponding limbs are converted into grasping organs by the device already exemplified among various air-breathing Arthropods (pp. 114, 117); that is to say, the end-joint can be folded back upon the rest of the limb. Lobsters, Prawns, and Shrimps are all members of the Large-tailed Decapods, this region of the body being used like a fin, enabling the animal to dart rapidly backward through the water. Related forms are also to be found in fresh water, of which the most familiar is the Common Crayfish (*Astacus fluviatilis*), which is a notable scavenger, not limited in its diet, however, to animal matters, though it would seem to prefer food of that kind. It is said to make foraging expeditions in the neighbourhood of its native river, seizing worms, insects, snails, and any other small animals that happen to be available. Tropical rivers are the home of monstrous Prawns, such as the Jamaica Prawn (*Palæmon Jamaicensis*), found both in the West Indies and Central America, and remarkable for the enormous development of its pincers.

Returning to marine Long-tailed Decapods, we find an interesting species in the spiny-looking Rock-Lobster (*Palinurus vulgaris*) (see vol. i, p. 412), in which the seizing limbs are constructed on the same type as those of the Shrimp. The value of the tail as a swimming organ is here diminished by the fact that the tail-fin is quite soft, and this creature is commonly in the habit of "sitting" in wait for prey, with its soft fin pushed into a crevice among the rocks for protection. This case leads on naturally to the interesting forms known as HERMIT- or SOLDIER-CRABS, which are commonly included in the "Crabs" or Short-tailed Decapods, but are better considered as intermediate between these and the lobster-like forms. Taking such an example as the Common Hermit-Crab (*Pagurus Bernhardus*) (fig. 403), we shall find that it uses as a dwelling the shell of a gastropod mollusc, and is markedly asymmetrical in accordance with the shape of its

abode. In this instance the whole of the tail is soft, and the last pair of limbs, which in a lobster make up the sides of the tail-fin,

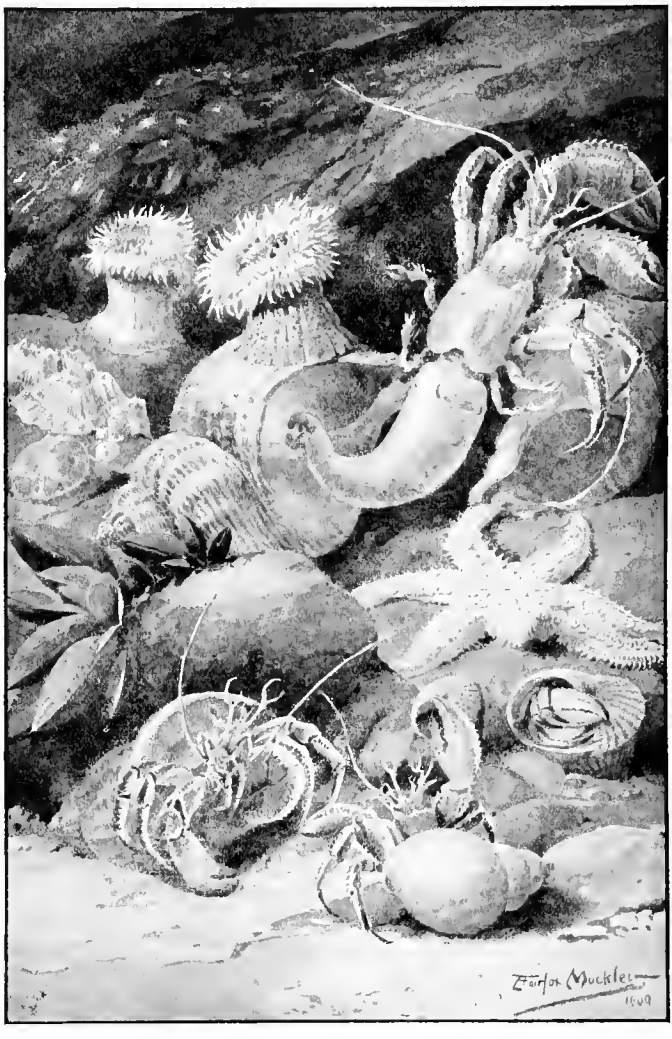


Fig. 403.—Hermit Crabs (*Pagurus Bernhardus*). One is taking possession of a new and larger house.

are here modified into hooks for holding on to the inside of the shell. These animals are highly predaceous in habit, and also, as one of their common names indicates, extremely pugnacious.

From Hermit-Crabs we pass to CRABS proper, constituting the Short-tailed Decapods (see vol. i, p. 411). The tail, in fact, is so short and small as to be useless as a swimming organ, and

is carried bent forwards against the under side of the thorax, which, together with the head region, to which it is closely fused, is broadened out into a shape varying according to the kind of crab. Swimming having been given up in ordinary cases, compensation is provided by the possession of running powers, which may be of no mean order. Regarding the food of Crabs and their part in the economy of nature, Frank Buckland (in *Log-book of a Fisherman and Zoologist*), in describing a visit to the Brighton Aquarium, speaks as follows:—"Mr. Lawler kindly showed me the 'crabbery' in the naturalists' room, where these unfortunate things are kept alive in hundreds (they cost one penny for four) for the octopus's dinner. He dropped in a bit of fish among them. In a moment the crabs near rushed towards it. The crabs at a distance, perceiving that 'something was up', began to run also, just as Londoners will run to a fire, an accident, or any other gratuitous amusement provided for them by circumstances. In about half a minute there were at least twenty or thirty crabs fastened on to this one bit of fish—a living ball of crabs, in fact. The ball then began to roll. Some crabs fell off the ball on one side, while other crabs climbed up the ball on the other, and then the moving ball rolled away into the other end of the tank, the mass of crabs fighting, pushing, and pinching each other most gloriously."

"I imagine, therefore, crabs must be very selfish creatures, and that they act on the principle of first come first served. But yet, do we not learn from this scene the great use of crabs? that is, to sweep up and tidy the bed of the ocean. If these active, hungry, and unpaid little scavengers were not in existence, all sorts of dead creatures, fish, shells, &c., would accumulate, and foul the water; but the crab's business and delight is to eat up all he can find. Therefore, I admire the little crabs for doing their duty, even though they do it unconsciously. Crabs are, in fact, the rats of the ocean, ready to eat up all the garbage they can find."

So far as seizing organs, jaws, and gastric mill are concerned, a crab essentially agrees with a lobster. The group is a very interesting one, and will frequently be mentioned in various connections. It may here be remarked that the very numerous species live under the most various conditions. Many are shallow-water forms, others live in deeper water, down to 2500

fathoms, *i.e.* over 2¾ miles from the surface. Some, again, maintain themselves among floating sea-weed, as, for example, the little Gulf-weed Crab (*Planes minutus*), which is stated to have been pointed out by Columbus to his discontented mariners as a proof of the nearness of land, a good instance of the occasional usefulness of fallacious argument. It is also interesting to note that many marine forms have reacquired the power of swimming, though not in the old lobster-like fashion, for here progression through the water is brought about by the flattening of the hindmost pair of legs into oars, an arrangement which reminds us of those found in some aquatic insects. This, however, by no means exhausts the possibilities. A number of species, among which must be reckoned the common Shore-Crab (*Carcinus mænas*) pick up a living between tide-marks, and there are all gradations between these and thorough-going land-crabs, most of which, however, feed more or less on vegetable matter, and therefore do not fall to be considered under the present section. The Swift Land-Crabs (*Ocypodidæ*) (fig. 404) may be instanced as a carnivorous section of the last-named group, living on sandy shores. Stebbing (in *A History of Crustacea*) speaks of them as follows:—"As the name *swift-of-foot* implies, these Crustacea are especially noted for their rapidity of movement. They are just the opposite of some of the strong-armed, thick-shelled, slow-moving *Cancridæ*, *i.e.* the group of which the common Edible Crab (*Cancer pagurus*) is a good type. On wind-swept stretches of sandy beach, and coloured like the sand, they sometimes seem rather to be borne on the wings of the wind than to run. Also, with their compressed lancet-like fingers they are extremely dexterous in digging into the sand. They burrow holes an ell deep, generally perpendicular, and from these they wander afar, when the tide is out, in search of food. Krauss observed in South Africa the species *Ocypode ceratophthalmus* (Pallas) and others, and he says that while they are busy hunting, every now and then they look carefully round, raising their stalked eyes upright, and standing upon tiptoe. At the slightest movement towards them they run with uncommon rapidity to the nearest hole, or, if the danger is too close, press themselves flat

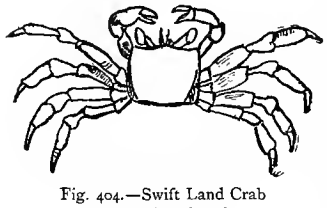


Fig. 404.—Swift Land Crab (*Ocypus*), reduced

on the sand till an attempt is made to seize them, and then off they dart. In running they carry their bodies high, doubling and dodging with such speed and cunning that it is a difficult matter to lay hold of them. When the tide comes up they are enclosed in their flooded burrows, and as soon as the waves retreat they are busily employed in clearing them, shovelling out the wet sand and heaping it at some little distance off. The American species, *Ocypode arenaria* (Catesby) is described by Professor S. I. Smith as having precisely similar habits. According to his observation, it lives largely upon the amphipods of the genus *Talorchestia*, known as 'beach-fleas', which inhabit the same localities. 'It will lie in wait', he says, 'and suddenly spring upon them, very much as a cat catches mice. It also feeds upon dead fishes and other animals that are thrown on the shore by the waves.'" It may be finally noted that some Crabs are inhabitants of fresh water.

Mantis Shrimps (*Stomatopoda*).—In such a typical member of this group as the common Mantis Shrimp (*Squilla mantis*) (see vol. i, p. 411), found to some extent in British seas, the structure is clearly adapted to a predaceous life. The feelers and stalked eyes are well developed, and there are powerful seizing organs. These are not, however, the same pair of specialized appendages as in a lobster, but correspond to the second pair of foot-jaws in that animal (vol. i, p. 406). But here, instead of three pairs of jaws and three pairs of foot-jaws, we find two extra pairs of the latter. The seizing organs do not end in pincers, but, as in several cases already described, have a blade-like end-joint which can be bent back on the rest of the limb. Mantis Shrimps excavate deep burrows in the zone below low-tide mark, and lie in wait for prey at the mouths of these.

HIGHER CRUSTACEA—SESSILE-EYED FORMS
(Edriophthalmata or Arthrostraca)

The Sessile-eyed Crustacea (*Edriophthalmata*) derive their name from the fact that the eyes project directly from the head instead of being situated on stalks as in the forms so far considered. The large majority of them are to be found in shallow water and on the shore, and are by no means restricted to salt water. Many of them play an important part in scavenging

the strand, not a few are parasitic, and some have become adapted to a terrestrial life. They include the Amphipods, such as Sandhoppers and their allies, which are flattened from side to side, and the Isopods, which are flattened from above downwards.

AMPHIPODS.—A very common example is the Sandhopper (*Talitrus locusta*) (see vol. i, p. 415), which haunts the shore between tide-marks, and in summer may be seen in countless thousands, springing several inches into the air so as to be visible some way off, and looking almost like a quivering dust-cloud hanging over the surface of the sand. Like most members of its group, the Sandhopper lives chiefly, if not entirely, upon decomposing animal matter, and close examination with the aid of a powerful lens shows it to be possessed of strong biting mandibles, two pairs of maxillæ (see Lobster, vol. i, p. 406), and a single pair of foot-jaws turned forwards so as to form a sort of lower lip. In northern latitudes Crustacea of related kind occur in such vast numbers as to be able to speedily do away with the stranded and putrefying carcasses of even such large Cetacea as whales and the like. An abundant and typical example of freshwater forms belonging to the same group is the Freshwater Shrimp (*Gammarus locusta*), and it may be observed in passing that the term "shrimp", popularly applied in the case of this and many other forms, is somewhat misleading, for the true shrimps, with their stalked eyes and firm shield covering the head and thorax, belong to the totally distinct and higher group of Decapods (see vol. i, p. 410).

Climbing about among sea-weed and zoophytes, in the tide-pools of the British and many other coasts, we can often find the weird-looking Skeleton-Shrimp (*Caprella*) (see vol. i, p. 415), typical of a subdivision of the Sandhopper group, and distinguished by an extraordinarily attenuated body. The abdomen is here reduced to a mere tubercle, and the thorax is correspondingly well-developed, its third pair of limbs bearing large climbing-claws, while at its hinder end are three pairs of legs. Jaws and foot-jaws are present as in a sandhopper, and behind the latter come the second thoracic limbs, specialized into seizing organs. Caprella may often be seen holding firmly to a zoophyte and waiting patiently for booty, the presence of which is made known by its two well-developed pairs of slender feelers. The

curious "Whale-lice" found as parasites on the skins of Cetaceans are related to the Skeleton-Shrimps, though of very different proportions.

Isopods.—Probably the best-known member of this group to ordinary observers is the Wood-Louse (*Armadillidium vulgare*), which rolls itself into a ball when disturbed; but as this and its terrestrial brethren are largely or mainly vegetarian in habit, they require no further mention here. Although by no means all of the marine forms are carnivorous, many of them are markedly so, and this is the case with the familiar "slaters" found lurking in rock-crevices between tide-marks. The Sea-Slater (*Ligia oceanica*) (fig. 405), *e.g.*, and the species of the shallow-water genus Idotea, are predaceous. Other examples are found in the species belonging to the genus *Cirolana* (see vol. i, p. 415), for which, as in so many other cases, only scientific names can be given. Speaking of one of these species (*C. borealis*) Stebbing says (in *A History of Crustacea*):—"It is a good swimmer, tenacious of life, a savage devourer of fish, and not to be held in the human hand with impunity". An allied American species preys upon an edible variety of crab. As may be imagined, well-developed biting jaws are present in such rapacious forms as those just mentioned. The marine Isopods also include a remarkable series of forms parasitic upon fishes and higher Crustacea. Some of these are so remarkably degenerate, as a result of their dependent mode of life, that they have lost all outward resemblance to their free-living relatives.

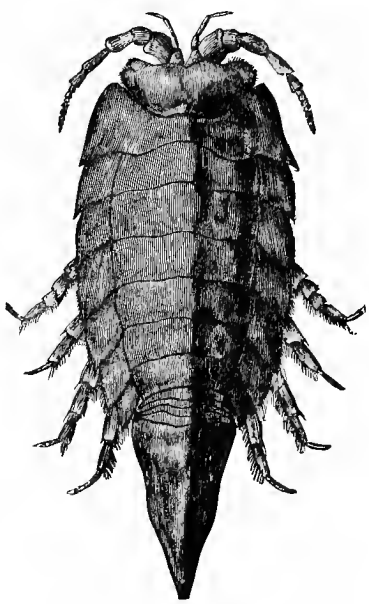


Fig. 405.—Sea-Slater (*Ligia oceanica*)

The group has also freshwater species, of which one, the Water Wood-Louse (*Asellus aquaticus*), is often to be found among rotting vegetation, feeding upon both animal and vegetable substances.

LOWER CRUSTACEA (ENTOMOSTRACA)

The innumerable marine and freshwater Crustacea which come under this heading, and which are commonly of small or very small size, mostly feed upon minute organisms belonging indifferently to the plant or animal kingdoms, and therefore do not fall under this section. Two of the included orders, however, embrace parasitic species, *i.e.* the COPEPODA, to which belong "fish-lice", and the CIRRIPEDIA or Barnacle order, in which are placed a number of strangely-shaped forms parasitic upon other Crustacea, or it may be upon animals belonging to other groups. These will receive mention when the question of Parasitism is discussed.

KING-CRABS (XIPHOSURA)

Having dealt with a few of the carnivorous forms belonging to the Crustacea, we come to the second class of gill-bearing Arthropods, *i.e.* the XIPHOSURA, including only the recent King-Crabs (see vol. i, p. 423), regarding the classificatory position of which there has been much discussion. They inhabit shallow water along the eastern coast of the United States and the south-east of Asia. The animal is of considerable size, and is covered on its upper side by firm protective armour, there being a strong horse-shoe-shaped shield (whence the popular name of "horse-shoe crab") extending over head and thorax, and a large plate on the abdomen, to the hind end of which a long movable spine is attached. Upon the under side of the body the mouth is seen as a longitudinal slit surrounded by the rough and spiny bases of the six pairs of walking legs, all of which, except the last, are, in the female, provided with pincers, while in the male the first pair present the common arrangement of a seizing organ in which the end-joint can be turned back upon the rest of the limb. The rough bases of the limbs act as jaws, and this is probably to be looked upon as the simplest case of the modification of a limb for this purpose, since the original use as a leg is still retained, though in this particular instance chewing duties have also been added. The foot-jaws or maxillipedes, of which examples have been described among the Crustacea (see pp. 141 and 142), represent a still further stage in the development of jaws, where the locomotor function has been

given up, though the outward resemblance to a leg is still more or less apparent. King-Crabs are found where the sea-bottom is composed of mud, upon the surface of which they crawl, aided by the shoving action of the tail-spine, which is further used to right them if accidentally turned over. They also burrow into the mud, largely aided by the last pair of legs, the ends of which are peculiarly modified, and by the tail-spine, which is employed as a prop. The food consists of bivalve molluscs and marine worms, which are chewed between the bases of the legs.

CHAPTER XII

THE FOOD OF ANIMALS—CARNIVOROUS ANNELIDS AND SIPHON-WORMS

We have next to consider typical carnivorous members of the phyla ANNELIDA, which includes Bristle-Worms (Chætopoda) and Leeches (Discophora), and *Gephyrea* (Siphon-Worms).

BRISTLE-WORMS (CHÆTOPODA)

All the members of this group have their bodies clearly divided into a number of successive rings or *segments*, the number of these varying in different cases. A further character of importance is the possession of firm bristles or *setæ*, imbedded in the sides of these segments, and sometimes very numerous and obvious, as in the marine Annelids (Polychæta), or else, as in the terrestrial and freshwater Annelids (Oligochæta), comparatively few in number. We are here only concerned with the marine species, and for the present purpose it will suffice to draw a distinction between the free-living or errant forms which swim, creep, or it may be burrow, and sedentary forms which inhabit temporary or permanent tubes of various kinds. As one would naturally expect, it is among the former that are included the typically predaceous species. A common kind, the Sea-Centipede (*Nereis*), has already been described (vol. i, pp. 425–429), and it is obviously specialized in accordance with its carnivorous habits. A large field of activity is afforded by the possession of several modes of locomotion—swimming, by means of general undulations of the body; crawling and burrowing, with the aid of blunt bristle-carrying *foot-stumps* arranged along either side of the elongated trunk. As in predaceous animals generally there are abundant sense organs serving to detect prey. The foot-stumps are provided with *tactile filaments* (cirri), and the well-developed head carries a number of *feelers*

of similar kind, as well as four *eyes*. The most extraordinary arrangement, however, is to be found in the *seizing organs*. Nothing is present at all comparable to the jaws or seizing limbs of many backboned animals, nor are there jointed limbs, which, as we have seen, are specialized for this purpose in both air-breathing and gill-bearing arthropods. But the food-tube begins with a muscular pharynx, which can be protruded so as to bring into play a pair of formidable horny *jaws* which project from its cavity. These having seized the prey, a reverse action takes place, bringing it within the body. Small crustacea, molluscs, and sponges are the chief articles of diet.

Comparable to the preceding in respect of its food, though with weakly-developed jaws, is the Sea-Mouse (*Aphrodite aculeata*) (fig. 406), which, however, is not a swimmer. Here the body is

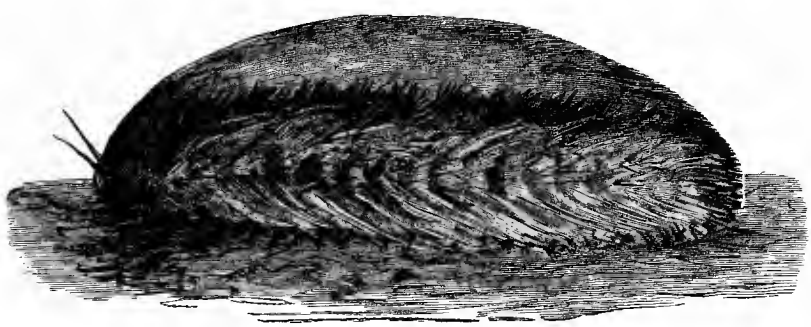


Fig. 406.—Sea-Mouse (*Aphrodite aculeata*)

short and broad, and there are very numerous elongated bristles of beautifully iridescent appearance. The upper side is also covered with a sort of loose skin composed of innumerable small bristles matted together so as to enclose a space above the skin proper.

LEECHES (Discophora)

Most of these are entirely devoid of the bristles so characteristic of the preceding group, and there is a sucker at either end of the body, the mouth-opening being in the middle of the front one. Leeches are divided into those possessing jaws and those devoid of these structures.

Jawed Leeches.—The common Medicinal Leech (*Hirudo medicinalis*) (fig. 407) is a familiar freshwater type of the jaw-bearing kind. It moves about either by swimming in an undu-

lating manner or by creeping with the aid of its suckers, which are alternately attached to the surface upon which it progresses. Although devoid of the obvious feeler-like structures seen in such a worm as the sea-centipede, it is nevertheless richly provided with organs of sense, there being transverse rows of tactile structures on the upper surface, and a number of peculiar eyes on the upper margin of the head. Attaching itself by the front sucker to the body of its victim, it cuts through the skin with

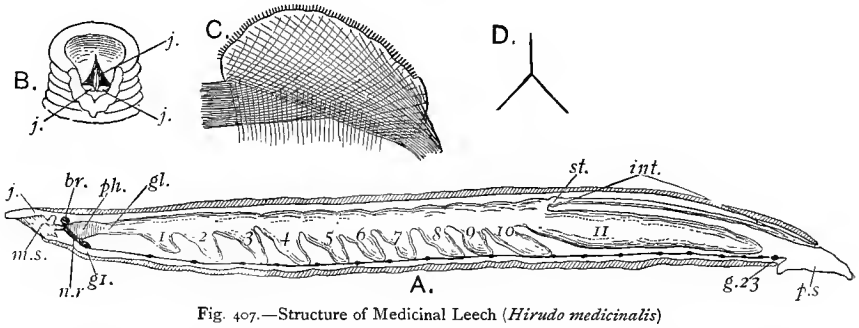


Fig. 407.—Structure of Medicinal Leech (*Hirudo medicinalis*)

A, Dissection from side: *m.s.* mouth-sucker; *p.s.* hind sucker; *j.* a jaw; *ph.* pharynx; *gl.* gullet; 1–11, pouches of crop; *st.* stomach; *int.* intestine; *br.* brain; *n.r.* nerve-ring; *g1* and *g23*, first and last ganglia of ventral cord. B, Mouth-sucker cut open from below, showing the three jaws, *j. j. j.* C, A jaw with its muscles and saw-like edge. D, Three-rayed bite. C and D much enlarged.

three horny saw-edged jaws that project into the beginning of its digestive tube, the result being a three-rayed incision admirably adapted for the exit of blood, which is pumped out by means of the muscular pharynx, that alternately dilates and contracts so as to constitute a sort of suction-pump. It should further be added that a number of small glands open into the pharynx and pour out a fluid which prevents the blood from clotting, as otherwise the sucking process would be hindered. The greater part of the food-tube consists of a very large crop, the sides of which are drawn out into pairs of pouches, an arrangement which permits a large quantity of blood to be stored up for leisurely digestion. It is therefore not surprising that a single full meal goes a long way.

Blood-sucking Leeches are by no means limited to an aquatic life, and it is notorious that in tropical regions innumerable Land-Leeches harbour among damp vegetation, from which they sally forth to attack all sorts of warm-blooded animals, human beings not excepted. Many travellers have given vivid accounts of the operations of these unpleasant creatures.

It must not, however, be supposed that all the jawed Leeches are blood-suckers. Some of the terrestrial forms, for instance, live upon earth-worms, and many of the aquatic species also live upon small invertebrates. This is the case in the well-known and much-slandered Horse-Leech (*Aulastomum gulo*), in which the jaws are not nearly so well developed as in the medicinal form.

Jawless Leeches make up for this deficiency by having the front part of the digestive tube in the form of a muscular tube which can be turned inside out and used for boring into prey, from which the juices are then extracted by the pumping action of the pharynx. Many of these forms are parasitic upon fishes, both marine and freshwater, while others, such as the freshwater genus Clepsine, live upon molluscs and other invertebrates.

SIPHON-WORMS (Gephyrea)

Passing by the phyla including the much-specialized worms known as Moss-Polypes (Polyzoa), Lamp-Shells (Brachiopoda), and Wheel Animalcules (Rotifera), of which the average members can scarcely be called carnivorous, though they feed to a great extent upon animal matter, we come to the equally peculiar phylum of Siphon-Worms (*Gephyrea*). This is a very heterogeneous assemblage of animals which, though they have lost external traces of segmentation, are usually regarded as being descended from ancestral forms of the nature of segmented worms. They are exclusively marine, and many of them, as the common Siphon-Worm (*Sipunculus nudus*), swallow sand for the purpose of extracting the nutritious organic matter which it contains. One of the included groups, however, which may perhaps be called the Bristly Siphon-Worms (*Echiuroidea*), embraces at least some carnivorous species, though, as in so many other cases where the habits of animals are concerned, there has been a dearth of observation. None of the species are familiar except to the professional zoologist, and as one consequence of this it is necessary to use the scientific names in speaking about them. The bodies of these creatures are plump-looking and more or less cylindrical, while it is usual to find a certain number of bristles imbedded in the skin which have been compared to the similar but more numerous structures found in bristle-worms. A remarkable peculiarity is found in the presence of a narrow, very extensible

proboscis, which projects from the front end of the body, and is used both as an organ of locomotion and for the purpose of detecting and securing prey. A groove runs along its under surface, and at the back end of this the mouth is situated. One example must suffice, the Green Bonellia (*Bonellia viridis*) (fig. 408), which has been the subject of very careful observation in the aquarium of the Zoological Station at Naples. The female has a fat green body some 2 inches long, and provided with a very long proboscis, forked at the end, and several inches in length even when in a quiescent state. The animal lurks in a rock-crevice or under a stone, and stretches out its proboscis in all directions in search of food, attaining in extreme extension the almost incredible length of nearly 5 feet, when it looks like a slender green thread. Should the forked end of this organ come into contact with the soft body of a small ascidian or other suitable prey, this is torn from its attachment and passed down the groove to the mouth.



Fig. 408.—Green Bonellia (*Bonellia viridis*). Female on left, male (much enlarged) on right.

CHAPTER XIII

THE FOOD OF ANIMALS—CARNIVOROUS UNSEGMENTED WORMS AND ECHINODERMS

One of the phyla which include typical unsegmented worms next claims our attention, *i.e.* FLAT-WORMS (Platyhelmia). Of the three classes which it includes, two—the TAPE-WORMS (Cestoda) and FLUKES (Trematoda)—embrace forms which are greatly modified as the result of a parasitic habit. Typical instances have already been briefly described (vol. i, chap. x), and further details will be given in the section on Parasitism. The third class, that of the PLANARIAN WORMS (Turbellaria), comprises an immense number of predaceous forms, differing greatly in size, shape, and colour, and found in the sea, fresh water, and among damp land vegetation. The *mouth* is remarkably variable in position, but it is always on the under surface, though in different species it may be far forwards, in the middle, or a long way back. A thick-walled *pharynx* can be protruded and used to perforate the small animals serving as prey, from which the juices and succulent parts are then sucked. Innumerable microscopic rods are imbedded in the skin, from which they can be shot out, serving, it would appear, both as offensive and defensive structures, though their mode of action is not clear. Locomotion is effected by creeping, and aquatic forms can also swim by undulations of the flexible body. Organs of touch and eyes are present, especially at the front end of the body, and these are efficient enough to enable their possessors to detect their prey by night as well as in the day. Three groups are distinguished, which differ among other things in the shape of the digestive tube, *i.e.* marine species, Polyclades, in which the gut is much branched; marine, freshwater, and terrestrial forms, Triclades, with the digestive tube divided into three main branches; marine, freshwater, and terrestrial forms, Rhabdocœles, in which the gut when well-developed is a simple tube.

Polyclades are distinguished by the extreme thinness of the oval or leaf-shaped body, which is often so closely pressed against a stone or other firm body as to be difficult to detach without tearing. The feeding habits have to some extent been observed in certain cases. The common British species *Leptoplana tremellaris*, for example, includes marine bristle-worms among its prey, enveloping them within its pharynx, which, when protruded, assumes the form of a frilled funnel (see vol. i, p. 446). It is suggested that the peculiar rodlets which can be ejected from the skin have previously been used to overpower the victim, and that weakly specimens are most liable to attack. Once within the pharynx a powerful digestive juice is poured out upon the food, which in a softened condition is drawn back into the stomach for complete digestion. One form (*Prosthiostomum*), in which the mouth is placed far forwards, possesses a long tubular pharynx which can be rapidly protruded, proboscis fashion, and used to secure small worms.

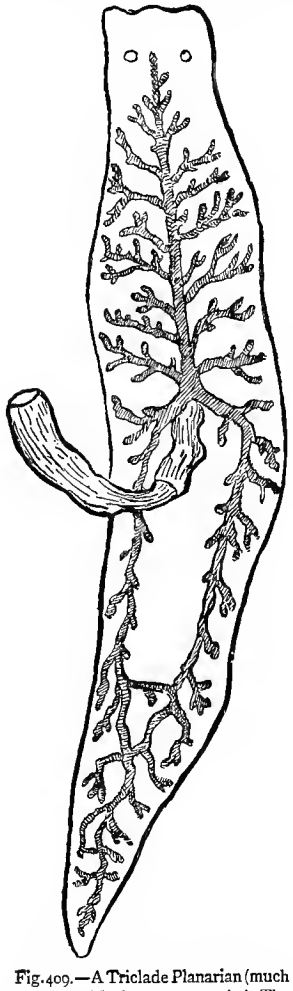


Fig. 409.—A Triclade Planarian (much enlarged), with pharynx protruded. The branched gut is seen within the body.

More numerous observations have been made upon the Triclades (fig. 409), which are highly carnivorous and, as in the preceding group, use the pharynx as a weapon of offence, pushing it out from the centrally or, it may be, backwardly situated mouth. There is little doubt that in this group also the rodlets shot out from the skin exert a paralysing influence upon the prey. The freshwater specimens are known to attack worms, water-snails, and water-beetles, among other invertebrate forms. Land Planarians, which belong to this group, feed to a very large extent upon earth-worms, some of them being adapted to pursue these creatures underground, capturing them with the help of a sticky fluid poured out upon the under surface.

Some, at least, among the Rhabdocœle species are carnivorous in habit, and certain marine species are parasitic.

HEDGEHOG-SKINNED ANIMALS (ECHINODERMATA)

The large and characteristic phylum of the Hedgehog-skinned Animals, or ECHINODERMATA, to which Sea-Lilies, Feather-Stars, Star-Fish, Brittle-Stars, and Sea-Urchins belong, does not include a majority of carnivorous species. The most characteristic forms in this respect are undoubtedly the Star-Fishes, of which the Common Star-Fish or Five-Finger (*Uraster rubens*) may be taken as type. Crawling slowly along by means of the innumerable tube-feet, which protrude from five grooves on the under side of the body, the central mouth (from the neighbourhood of which these grooves radiate) is from time to time brought into the neighbourhood of some desirable bit of food in the form of a mollusc, crustacean, or other animal. Then follows a process which reminds one of what takes place in a planarian worm, for while the clinging body of the Star-Fish holds down the booty, a large pouch-like stomach is protruded, which folds itself round the desired object and, having enveloped it, is drawn back by special muscles into the interior of its owner, where the process of digestion is carried on. Star-Fishes appear to be among those animals which do scavenging work; and Mr. Saville Kent is inclined to think that this is part of their business in oyster-beds, where they are usually believed to play havoc among the inhabitants. Regarding them this author (in *The Great Barrier Reef of Australia*) writes as follows:—"Star-Fishes of all descriptions, but more especially the ordinary five-rayed varieties, Asteriadæ, are universally held up for condemnation as representing the most insatiable foes of the oyster tribe. Whether this wholesale condemnation is a just one there are some reasons for doubting. In many instances it has been observed that the star-fishes were merely acting as scavengers and preying on dead or dying bivalves. The direct experiment was carried out by the author some years since, in one of the large English public aquaria, of keeping oysters and star-fish, including the accredited most aggressive species, *Asterias* (*Uraster*) *rubens*, in the same tank. The pre-supposed aggressors and their helpless victims were thus maintained side by side in perfect health for many months without a single instance occurring of molestation of the oysters on the part of the star-fish. The Echinoderms, however, demonstrated their possession of normal healthy appetites

by feeding freely on portions of cut-up fish occasionally placed in the tanks." It has been proved that Star-Fishes are largely guided in their hunt for food by the sense of smell, and this is a common characteristic of many scavenging animals. On this subject Romanes (in *Jelly-Fish, Star-Fish, and Sea-Urchins*) describes his observations in these words:—"The presence of a sense of smell in star-fish was proved by keeping some of these animals for several days in a tank without food and then presenting them with small pieces of shell-fish. The star-fish immediately perceived the proximity of food, as shown by their immediately crawling towards it. Moreover, if a small piece of the food were held in a pair of forceps and gently withdrawn as the star-fish approached it, the animal could be led about the floor of the tank in any direction, just as a hungry dog could be led about by continually withdrawing from his nose a piece of meat as he continually follows it up."

CHAPTER XIV

THE FOOD OF ANIMALS—CŒLENTERATES, SPONGES, AND PROTOZOA

Passing downwards in the animal scale we come to the innumerable marine forms, often of extreme beauty, which are grouped together in the phylum CŒLENTERA, and include Zoophytes, Jelly-Fish, Sea-Anemones, Corals, and Comb-Jellies. Three classes are recognized:—(1) CTENOPHORA, Comb-Jellies; (2) ANTHOZOA, Sea-Anemones and most Corals; (3) HYDROZOA, Zoophytes, Jelly-Fish, and some Corals. The creatures embraced by these three classes are all actively predaceous, and the methods of capturing prey will be described with reference to a few typical forms.

COMB-JELLIES (CTENOPHORA)

A common British Comb-Jelly, Cydippe (see vol. i, p. 483), has a translucent body shaped like a small melon, which is rowed through the water by eight longitudinal rows of little paddles, which suggest by their appearance the teeth of a comb, hence the word Ctenophora (Gk. *cteis*, a comb; *phéro*, I carry) and its popular equivalent. The digestive organs are represented by a complicated system of canals traversing the jelly-like body, and opening by a mouth at the end which is kept hindermost during swimming. Two long branched *tentacles* protrude from pouches in the side of the body, and can either be extended to a relatively great extent or else withdrawn altogether from the surface. These tentacles are veritable fishing-lines which capture the food, consisting largely of minute crustaceans, by means of innumerable minute sticky knobs with which they are beset. Should the victims attempt to escape they are "played" by the straightening out of the elastic spiral stalks with which these knobs are provided, and when exhausted are conveyed to the mouth.

In another common type, Beroë (fig. 410), there are no fishing-lines, but the body is shaped like an elongated pointed cap, the wide opening of which is to be regarded as a mouth. Some of the species are of large size, and swimming is largely effected by the alternate contraction and relaxation of the walls of the body. The prey consists to a great extent of other sorts of comb-jellies, and there is small chance of escape for any of these which are so unfortunate as to be engulfed within the capacious central cavity of this voracious cap, provided as it is with hooks.

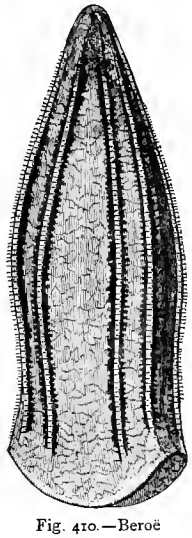


Fig. 410.—Beroë

SEA-ANEMONES AND TYPICAL CORALS (ANTHOZOA)

A brief description of a Sea-Anemone has elsewhere been given as illustrative of the structure of this class (see vol. i, p. 473). We are here concerned with the capture of prey, and at first sight a fixed animal, which resembles when extended a brilliantly-coloured flower, does not appear capable of playing havoc with its neighbours—certainly not with such forms as fishes and crustaceans (fig. 411). Appearances, however, are unusually deceptive in this case, for the innocent-looking "petals" are aggressive *tentacles*, armed with innumerable "nettling organs", and they surround a large mouth which can be easily stretched so as to admit prey of comparatively large size. The *modus operandi* is graphically described by Fred Smith (in *The Boyhood of a Naturalist*). The boy has brought home from the sea-side his first collection of marine animals, including a large contracted anemone, of which its donor, a friendly fisherman, had said: "If he blows, he'll astonish you; and if he ain't hurt he will, purviding you put him into some of your fresh sea-water when you get



Fig. 411.—A Sea-Anemone. Notice mouth surrounded by tentacles.

home". Then follows the sequel. "When put into the fresh water the diseased-looking potato had fallen to the bottom of the bottle, and lay there apparently dead as any potato ever was. And now—can words describe it?—it was three times its former girth, and rose up like some green-and-red-striped cactus plant, two-thirds the height of the bottle, where it burst into a myriad delicate grey-green petals, which merged at their base into as delicate a pink, and they radiated at the top exactly like the florets of a chrysanthemum, and in such luxuriance that the bottle was not nearly wide enough for their free expansion." Two brothers of unscientific tendencies are then introduced to the marvel, "when someone, out of the purest mischief, dropped one of my live shrimps right on to the top of it, and then a curious thing happened. Instead of the anemone closing up, it seemed to expand itself more fully; the shrimp, after only one or two attempts to dart about, was distinctly taken hold of, so to speak, by the petals or tentacles of the anemone, and then it gave up in the most unexpected manner all attempts even to struggle. When I say the 'petals' held the shrimp, they only seemed to touch it, and yet to securely hold it. In fact the shrimp seemed to become paralysed and utterly helpless, and then it was in a mysterious manner handed along over the top of the tentacles, they all bending slightly in sympathy towards the poor shrimp; and in, say, half a minute, it disappeared, without a struggle, into the mouth in the very centre of the creature, which, now that it behaved like an animal, looked like nothing else than an elaborately-decorated stomach." The present writer remembers on one occasion putting some healthy whiting into a small aquarium containing some expanded anemones. The fish came into contact with the tentacles of these, and with startling result, for next moment they were floating in a moribund condition, back downwards at the surface of the water. It may be worth while to examine rather more closely the nature and action of the "nettling organs", of which the action has just been described, and which are potent enough in many cases to pierce the human skin with painful results. Varying largely in the details of their structure, these organs are present in most of the animals included in the Anthozoa and Hydrozoa. The "nettling organs", "stinging-cells", or "thread-cells", as they are variously called,

are microscopic structures imbedded in the body-wall, and particularly abundant on the tentacles, where they are often aggregated into "batteries", giving rise to a roughened appearance as seen under strong magnification. Each of them (fig. 412) is a highly-modified cell, and before use looks like a little vesicle or bladder within which a thread is coiled up. The bladder contains a poisonous fluid, and its elastic wall is covered by a thin layer of living matter or protoplasm, from which a stiff "trigger-hair" projects to the exterior. The layer of living substance covering the vesicle has been described as in connection with a nerve-fibre, and this again with a nerve-cell. The coiled thread is hollow, and can be shot out to the exterior by pressure of the fluid in the vesicle, the motive power being supplied by the living layer, which is capable of contracting so as to exert a squeezing action. During the process the thread is necessarily turned inside out (see fig. 412), and the first part to emerge is provided externally with a varying number of backwardly-directed spines. The apparatus is under nervous control, and the animal undoubtedly exerts discriminative power, for the contact of, say, a sand-grain with the trigger-hair leads to no result. But if suitable prey, such as a shrimp, is the disturbing influence, the stinging-cell "explodes", *i.e.* the thread is rapidly protruded to the exterior, its spiny base inflicting a wound, and holding fast like a barbed arrow. Part or all of the rest of the thread is then ejected into the wound, and the poisonous fluid is able to exert its full effect. Should the victim struggle, and it often does, other tentacles are brought up to the attack, and it is eventually overcome by the action of a sufficient number of stinging-cells. These differ from the adhesive knobs of a Comb-Jelly in the fact that they can be only used once, and after explosion are cast off, being constantly replaced by the growth of others.



Fig. 412.—Thread-cells (greatly enlarged). The one on the right is exploded

CORALS.—Anemones are devoid of any hard parts, but their relatives the Corals (fig. 413) are well-endowed in this respect. The simplest Corals are solitary, and each of them has its base

AUSTRALIAN SEA-ANEMONES AND CORALS

(After Saville Kent.) Drawn to various scales

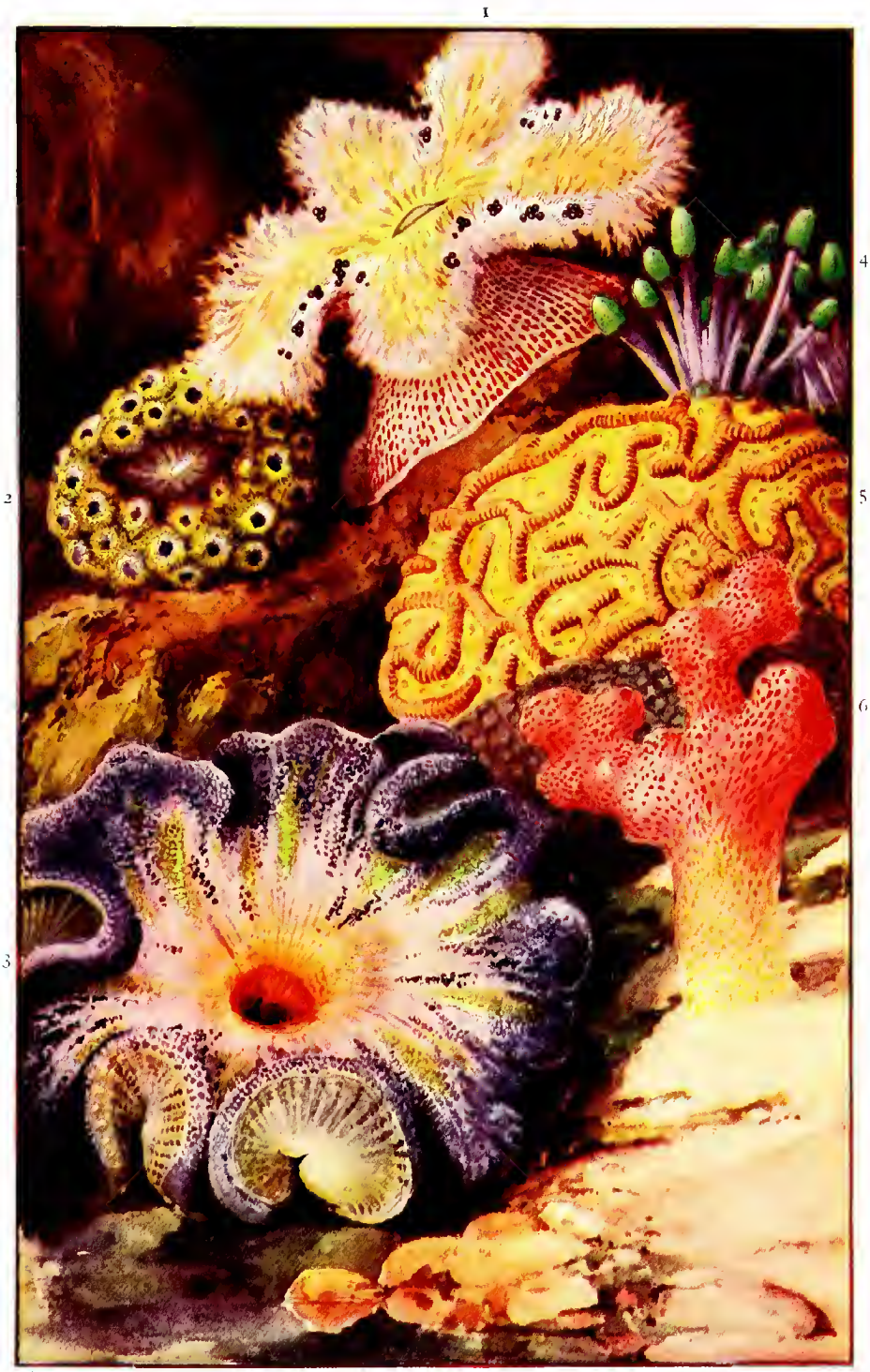
Among marine animals few possess such striking hues as Sea-Anemones and Corals. It would appear to be, at least in many cases, "warning coloration", by which these apparently defenceless creatures give notice of unpleasant qualities. They are, in fact, provided with innumerable microscopic stinging capsules, which make them inedible to most carnivorous fishes, &c.

ANEMONES

1. *Heterodactyla Hemprichii.*
2. *Heterodactyla hypnoides.*
3. Giant Anemone (*Discosoma Haddoni*). (Over 12 inches in diameter.)
4. *Physobrachia Douglasi.* (Only tentacles are seen.)

CORALS

5. *Cæloria.*
6. *Stylopora palmata.*



AUSTRALIAN SEA-ANEMONES AND CORALS

1. Heterodactyla Hemprichii. 2. Heterodactyla hypnoides. 3. Giant Anemone.
4. Physobrachia (tentacles). 5. Cæloria (coral). 6. Stylopora (coral).

supported by a flat or cup-shaped skeleton. The remaining Corals are colonies, formed by the budding of one primary individual. Each member of the colony is essentially like an anemone in structure, and the various individuals are connected together by a common body, just as the leaves of a plant are continuous with the branching stem. All sorts of shapes are assumed in different species. It may not be altogether superfluous to quote here the remarks of Saville Kent (in *The Great Barrier Reef of Australia*) about the once popular and even yet not altogether defunct fallacy which ascribes the formation of coral to an intelligent and industrious "insect".



Fig. 413.—A Branching Coral

"Notwithstanding the wide diffusion of knowledge, which includes a smattering of many ''ologies', it is astonishing to find how tenacious an influence ancient tradition concerning coral organization still exerts on the public mind. The poetic fallacy of coral-reefs being built up by an association of 'insects' between which there subsists a relationship analogous to that which obtains between the 'busy bee and its waxen cell' is frequently enunciated from the pulpit, and in the pages of the daily newspapers. . . . Doubtless there is a large section of the public whose zoological lore will ever remain restricted to the narrow limits of that of *Punch's* railway porter, who, puzzled as to the classification of the old lady's tortoise, declared that, being 'neither a dawg nor a bird, it must needs be a hinsec'. There is also a very large multitude to whom the term 'insect' includes everything not distinctly referable to the category of 'flesh, fowl, or good red herring'. . . . The coral animal . . . is, individually, a simple polyp, comparable in every essential detail with the ordinary simply-organized sea-anemone familiar to every sea-side or aquarium visitor, with the exception that it possesses the power of secreting a dense, calcareous, skeleton out of the lime held abundantly in suspension in probably every sea."

ZOOPHYTES, JELLY-FISH, AND MILLEPORE CORALS (HYDROZOA)

A simple example of this class is the common Freshwater Polyp (Hydra) (see vol. i, p. 465), which is practically a living stomach of cylindrical shape, attached by one end, which is closed, while in the centre of the other is a dilatable rounded mouth, placed at the apex of a conical projection. Around the base of this projection are arranged a number of hollow *tentacles*, richly provided with thread-cells, and capable of being stretched out for a considerable distance in search of prey. The branching sea-weed-like structures known as Hydroid Zoophytes (fig. 414) are in reality colonies of hydra-like individuals which capture prey by means of their tentacles. In many cases such colonies give rise to Jelly-Fish or Medusæ (see vol. i, p. 479) comparable in shape to an umbrella, the mouth being situated at the end of the handle. Other sorts of jelly-fish arise by the transverse division of certain simple zoophytes, and others again have no fixed stage in the life-history. In all cases nettling-organs are present in great abundance, especially upon slender *tentacles* with which the umbrella is fringed, and upon lobes and filaments placed in the neighbourhood of the mouth.

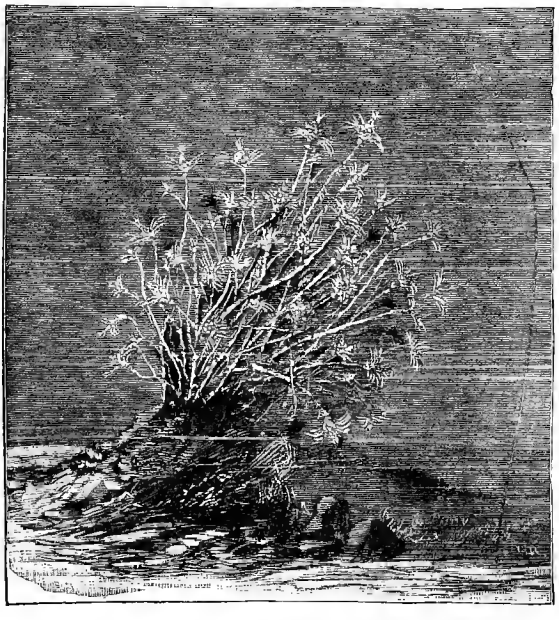


Fig. 414.—A Hydroid Zoophyte (*Tubularia*)

MILLEPORE CORALS.—A very interesting group of Hydrozoa is that containing certain corals, of which the Millepore Coral (Millepora) (fig. 415) may be taken as an example. This is a colony, of which the shape depends upon the species, and it is

interesting as exhibiting *division of physiological labour* between the members of the colony, a very common phenomenon in the animal kingdom. As regards nutrition we can distinguish between individuals which serve as stomachs, and slender mouthless individuals richly provided with nettling-organs and constantly fishing for prey. Each of the larger feeding individuals is surrounded by a circle of the fishers, which provide it with food. As all the members of the colony are connected together by the common flesh, anything which is caught and digested benefits all the neighbouring polyps more or less.

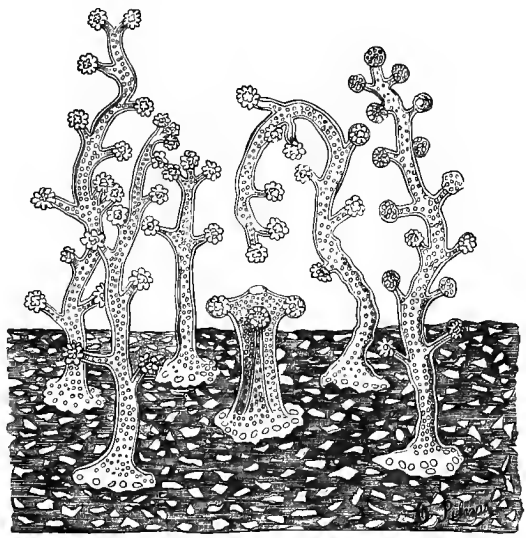


Fig. 415.—Group of individuals from a Millepore Coral (*Millepora*) (enlarged). A feeding individual surrounded by five fishers

Compound Jelly Fish. — Division of labour, however, is carried to a far greater extent in another group, that of the Compound Jelly-Fish (*Siphonophora*), including a large number of translucent free-swimming forms such as Diphyes, Physophora (fig. 416), and Velella.

Each of these is in effect a floating colony produced probably by the budding of an originally single jelly-fish, the shape of the colony being determined by the method of budding, whether from the under side of the original umbrella or from the surface of the much-elongated handle, which is converted in many cases into a long trailing stalk. The members of the colony, or it may even be the organs of certain members, are specialized in all sorts of ways to perform different functions. One may be a gas-containing *float*, others may be *swimming-bells*, and so on, but those which are of special interest in the present connection are trumpet-like *feeding-individuals* which receive and digest food for the common good of the colony, and slender often branching *fishing-lines* which trail in the water and capture prey. A good example is the Portuguese Man-of-war (Physalia), which

consists of a huge float to the under side of which other sorts of individuals are attached, including very long fishing-lines, of

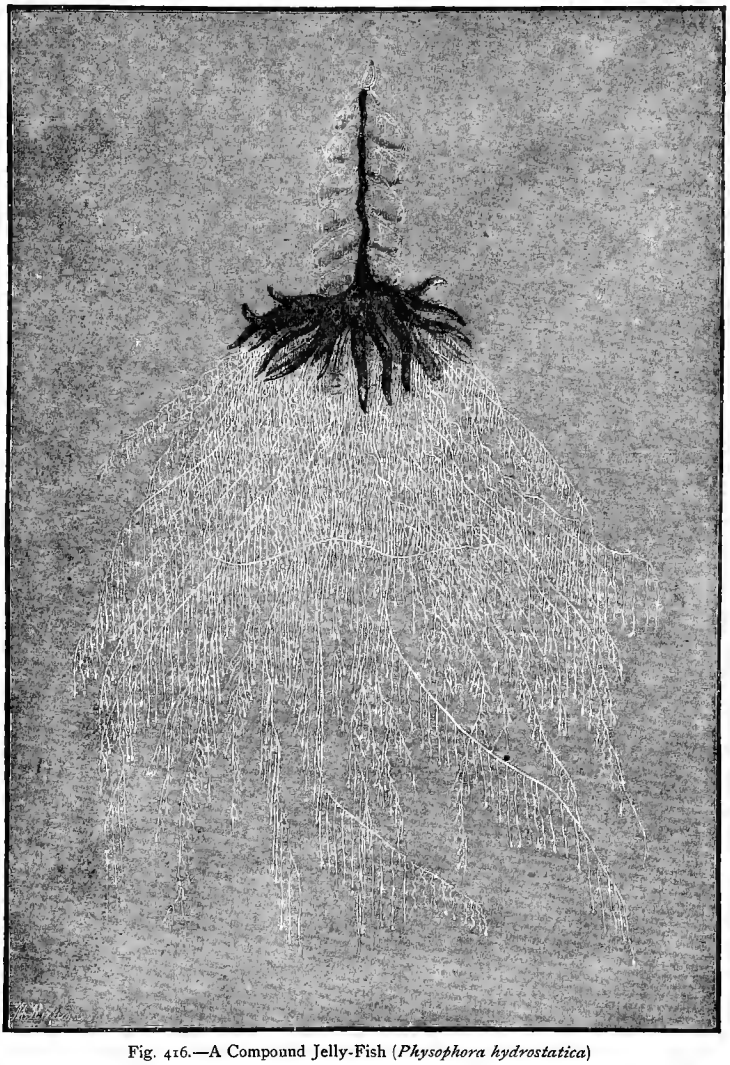


Fig. 416.—A Compound Jelly-Fish (*Physophora hydrostatica*)

At the top a small float. Below this a stalk bearing swimming-bells. Next follow protective covering-pieces (darkly shaded), from between which one of the trumpet-shaped feeding individuals is seen projecting. Branched fishing-lines trail below.

which the stinging organs are so numerous and powerful that they may seriously injure persons who are incautious enough to handle them.

SPONGES AND ANIMALCULES (PORIFERA AND PROTOZOA)

Comparatively little is known about the feeding habits of the animals belonging to the two lowest phyla of the animal kingdom—PORIFERA (Sponges) and PROTOZOA (Animalcules),—and as, apart from certain parasitic forms which will be dealt with elsewhere, the food is for the most part of mixed character, we may now proceed to consider a few types, from Mammalia downwards, in which there are interesting adaptations to a diet entirely or mainly of vegetable nature.

CHAPTER XV

THE FOOD OF ANIMALS—PLANT-EATING MAMMALS

So much space has been devoted to the consideration of carnivorous forms that the limits of this work will only permit of comparatively brief notice of animals which feed on vegetable matter; but the importance of this kind of food must not be under-estimated, since all animals are dependent upon it either directly or indirectly. Indeed, it may be said with truth that green plants (as opposed to fungi, &c.) are the primary source of living matter, since they alone are able to build it up from simple chemical compounds, including the carbonic acid gas of the air and the inorganic salts dissolved in the water of the soil.

Beginning with the phylum VERTEBRATA we will consider in succession the several classes, starting with the Mammalia.

MAMMALS

PRIMATES

It is but few of the highest order of Mammals, the PRIMATES (Man and Monkeys), that are adapted for a purely vegetable diet. Man himself, whatever vegetarians may say to the contrary, is specially suited to a mixed diet, as will appear in another section. The internal arrangements of mammals feeding entirely on plants have to be constructed on a special type, in order to deal successfully with the large bulk of food required, for prolonged digestion is necessitated, and also a large extent of absorbing surface. Among those monkeys which are mainly or entirely vegetable-feeders may be mentioned the Entellus Monkey (*Semnopithecus entellus*) (see vol. i, p. 72), held sacred among the Hindus, to whom it is known as the Hunuman. The canine teeth do not here attain the size and prominence that is so characteristic of many carnivorous mammals, nor are there

sharply-pointed cheek-teeth as in insect-eating forms; but these negative features are not so conclusive as the positive indication of plant-eating habit afforded by the *stomach*, which, instead of being a simple sac as in man and most monkeys, is complex, consisting of three separate divisions. Vegetarian mammals, notably the ruminating forms, commonly possess a complex arrangement of the sort. Reasoning from analogy, Owen, after studying the anatomy of monkeys of this group, put them down as leaf-eaters at a time when the nature of their food was a matter of conjecture. Subsequent observation proved the correctness of this surmise, as Entellus Monkeys and their kind feed largely on leaves and juicy shoots.

HOOFED MAMMALS (UNGULATA)

The majority of the animals included in the large and important order of UNGULATA are characteristically vegetable-feeders, though the omnivorous pigs and their allies form an important exception to this. It may be remembered that there are two sub-orders of Ungulates (see vol. i, p. 104)—(1) the odd-toed forms or Perissodactyles, including Tapirs, Rhinoceroses, and Horses; and (2) the even-toed species or Artiodactyles, including the non-ruminating groups of Swine and Hippopotami, and the ruminating animals embraced under the headings of Deer, Antelopes, Cattle, and Giraffes. It will suffice for the present purpose to devote most of our space to considering in detail the food and feeding of the Horse and Ox, highly specialized representatives of the two sub-orders. The points specially deserving consideration will be the means employed in securing food (prehension), and afterwards reducing it to a fit state for absorption into the blood and lymph.

The Horse (*Equus caballus*), like most grazing animals, spends a large part of its time with the head bent down to the ground, and if the raising of it, which is constantly necessary, were brought about by muscular action solely, a wasteful amount of force would be expended. But in such cases the greater part of the work is done by the elasticity of a strong *neck-ligament*, which runs from the back of the skull to the long spines of the chest vertebræ, and sends branches forwards to be attached to the joints of the neck. Herbage is gathered into the mouth by the agency of the lips, which are extremely sensitive and flexible. Regarding them,

Flower remarks (in *The Horse: A Study in Natural History*):—"Anyone who has seen a horse take a small piece of sugar from a child's hand will appreciate the delicacy and efficiency of these organs as instruments of prehension". Perissodactyles generally are distinguished by lips of this kind, and in the Tapirs (see vol. i, p. 105) the snout is produced into a short mobile *proboscis*, partly formed by extension of the upper lip. The nature of the food is commonly indicated by the characters of the *teeth*, and

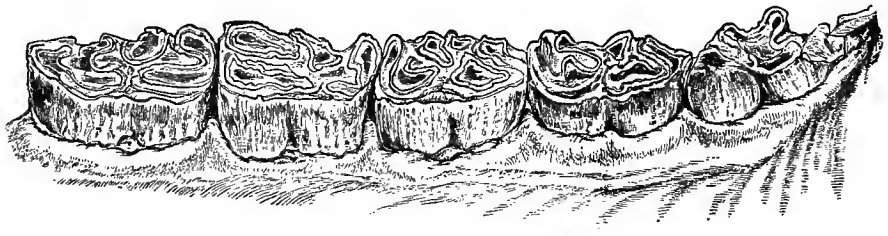


Fig. 417.—Complicated Grinding-teeth of Horse (*Equus caballus*)

this is strikingly exemplified in the Horse (fig. 417). Incisors for cutting through grass and the like are well developed in both jaws, but canines, not being required, as in the Carnivora, for seizing prey, are not well developed, and in the Mare are either entirely absent or represented by mere vestiges. Adaptation to vegetable food comes out strongly in the complex cheek-teeth, which possess long grinding crowns, marked by a complicated series of folds and ridges. And it is particularly noticeable that the projecting part or crown of a horse's tooth not only consists of hard *dentine* and very hard *enamel*, as in a human molar, but also of a great deal of a bony substance, *cement*, which fills up the "valleys" in the crown, instead of, as in simpler cases, being confined to a thin layer on the parts imbedded in the gum. In this way unequal wear is provided for by which the top of the crown is always kept rough, instead of wearing down to a smooth ineffective surface, as would otherwise be the case. The teeth of a tapir or rhinoceros are much less complicated than this, but a study of the genealogy of the Horse, as established by fossils, shows that in the course of ages comparatively short and simple cheek-teeth, not unlike those of tapirs, have gradually attained the specialized condition which is now so characteristic.

Herbivorous animals, in order to obtain the nutriment which they require, have to take in a comparatively large bulk of food,

and their digestive organs are of corresponding size. One result of this is that the abdomen is large as compared with the thorax, the proportions being reversed in carnivorous forms, which have to deal with a comparatively small bulk of highly nutritious matter. The Horse is not an extreme case, for it feeds little and often, as compared with some other forms living on the same kind of food, but the general proportions of its body are strikingly different from those of a dog or cat, for the reason indicated among others. Once swallowed, a large digestive and absorptive surface is necessary to deal successfully with vegetable food, and to meet this requirement the food-tube of herbivores is both long and more or less possessed of swollen regions. We have seen, for example, that the stomach of the leaf-eating Entellus Monkey is large and divided into several compartments. As to length, the Horse affords a good illustration of the principle, for its intestines are from ten to twelve times the length of the body, while in a cat they are only four or five times as long. The stomach of a horse is not specially capacious and its shape is simple, but an interesting feature may be noted in the character of its lining, which in the left-hand part is hard and tough, while in the right-hand portion it is soft and glandular, secreting the important digestive fluid known as gastric juice. In other words, the right-half region is that which is especially concerned with chemical digestion. The digestive tube of the Horse does, however, possess an exceedingly large dilated region in the blind pouch or *cæcum*, which grows out from the beginning of the large intestine. It is probable that this has to do with the digestion of plant-membranes, which are composed of *cellulose*, a substance which, though allied to starch and sugar in composition, is notoriously difficult to digest, as human beings often find to their cost if they swallow the skins of grapes, gooseberries, and other fruits.

Turning now to the Ox (*Bos taurus*), we find that, as in the horse, there is a strongly-developed elastic neck-ligament (the pax-wax of butchers), having the use already mentioned. The mouth is placed on a large blunt *muzzle*, and the lips are comparatively immobile, their food being grasped in this case by the large rough *tongue*, which is extremely flexible, and can seize tufts of herbage, drawing them into the mouth. The *teeth* present features which are characteristic of most common rumin-

ants. Cutting incisors are present in the lower jaw, and also canines which resemble them in shape, being quite unlike the lower tusks of Carnivores, to which they correspond. Front teeth, however, are entirely absent in the upper jaw, their place being taken by a hard elastic pad, against which the teeth below bite. The point is illustrated by the old story of the knavish dealer who sold some old ewes to a greenhorn as particularly fine lambs, pointing out as proof that the upper front teeth had not been cut. The cheek-teeth are complex grinders, something like those of the horse, but not nearly so specialized. Enormous *salivary glands* are present, in correlation with the starchy matter of which the food largely consists, and which is converted into sugar by the action of saliva and pancreatic juice. The internal digestive organs are exceedingly bulky, the intestines being from

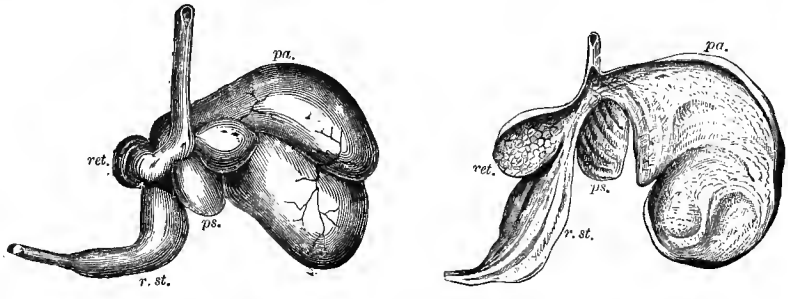


Fig. 418.—Stomach of Sheep (*Ovis arie.*

Shown cut open on right. The lower end of gullet is seen above and beginning of intestine to left. *pa.* Paunch; *ret.* honey-comb stomach; *ps.* manyplies; *r.st.* rennet stomach.

twenty to twenty-two times the length of the body, much longer than in the Horse, though not equalling the Sheep and Goat, where they attain as much as from twenty-eight to thirty times that relative length. The most remarkable peculiarity of the Ox and other ruminants, however, is found in the enormous and complex *stomach* (fig. 418), related to the habit of *rumination*, or, as it is popularly termed, "chewing the cud", which enables these animals to take in a large bulk of food very rapidly, and afterwards to masticate it at leisure. To this stomach there are no less than four compartments, as follows:—(1) An enormous *paunch* (rumen) on the left-hand side, and having about nine-tenths the entire capacity of the stomach; it communicates by a wide aperture with (2) the *honey-comb stomach* (reticulum), so called because its lining is raised into a net-work of prominent ridges presenting some re-

semblance to a honey-comb; this compartment opens into the (3) *manyplies* (psalter or omasum), the name of which suggests the fact that its lining is raised into numerous folds, projecting almost like the leaves of a book (such as a psalter or psalm-book, for instance) into its cavity; the manyplies is continued into the last compartment, (4) the *rennet stomach* (reed, abomasum), from which the small intestine leads out. The first three chambers are lined by a thick hard membrane, reminding us of the left-hand part of the horse's stomach, and it is not unlikely that in both cases we have to do with a dilated part of the gullet, comparable to the crop of a bird, and not really a part of the stomach at all. The fourth or last compartment is the true chemical stomach, and is lined by a soft membrane secreting the gastric juice. This contains pepsin, and also a milk-curdling substance (rennin), which is the source of the rennet used in cheese-making.

The food is cropped rapidly, and swallowed without being properly chewed, passing into the paunch. Here it gets into a sodden condition, and later on, when the animal begins to "chew the cud", is made up into boluses in the honey-comb stomach, and returned to the mouth for thorough mastication. While this is being effected the lower jaw is moved from side to side—from left to right, and right to left alternately—the articulation of the jaw being so constructed as to permit of this (see vol. i, p. 29). After the second and thorough chewing the food is conducted along a groove into the manyplies, which acts as a strainer, and thence into the rennet stomach, where gastric juice is poured upon it. The conditions of life under which the primitive ruminants existed account for the evolution of the complex stomach. The grass constituting their food would be most abundant on the plains, and here they would be exposed to the attacks of Carnivores. The power of rumination enables its possessor to rapidly obtain and swallow a large bulk of herbage, retiring afterwards to a place of safety, where the process of mastication can be completed at leisure.

It is a commonplace that ordinary ruminants, just like Lions and Tigers among the Carnivora, find their food on or near the ground; though some of them, Goats, for instance, rear up on their hind-legs so as to browse on leaves and shoots otherwise out of reach. It has, however, recently been shown that a common South African antelope, the Blue-Buck (*Cephalophus*

monticola), can climb trees to some extent, for a number of them have been seen feeding among small branches about 12 feet from the ground. An extraordinary though well-known device, by which leaves and shoots at a considerable height from the ground are rendered available as food is afforded by the immensely long neck of the Giraffe (*Giraffa camelopardalis*) (see

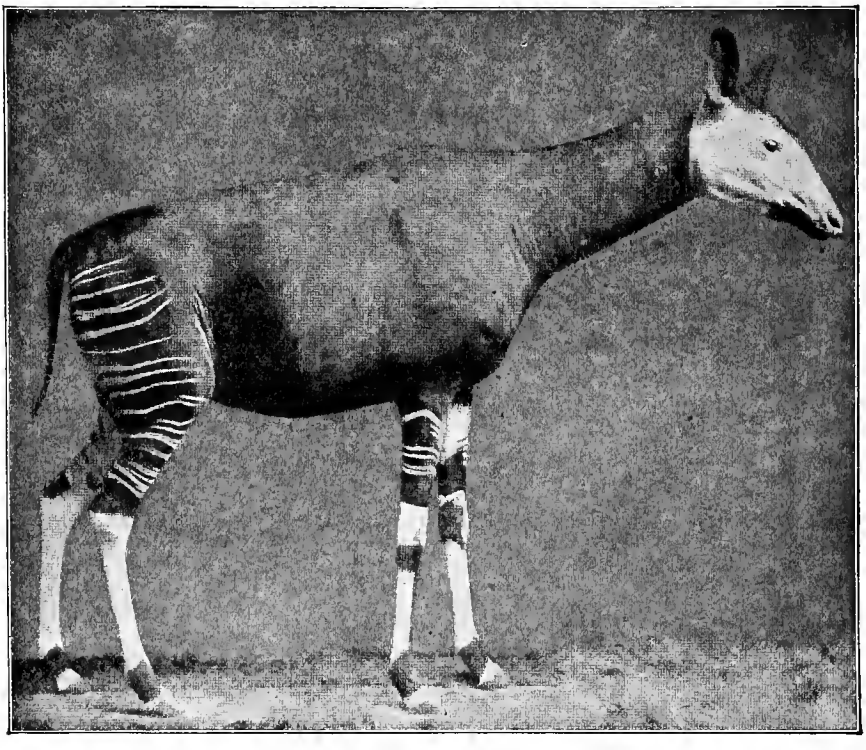


Fig. 419.—The Okapi (*Okapia Johnstoni*)

vol. 1, p. 120). Here, too, both lips and tongue are mobile, prehensile organs, and the latter is distinguished by its extreme length. The Okapi (*Okapia Johnstoni*) (fig. 419), recently discovered by Sir Harry Johnston in Central Africa, may broadly be described as a short-necked Giraffe, and is a kind of "half-way house" between its tall relative and other forms. The stuffed specimen which may be seen in the British Museum (Natural History) at South Kensington, possesses no horns, though there are bosses in the skull in places where horns might be expected (from comparison with Giraffe) to occur. This

specimen, however, is immature, and it is at present unknown whether the adult is hornless or not.

No mention of the feeding habits of Ruminants would be complete without allusion to the way in which the Camel (*Camelus*) is adapted, as regards drink, to desert conditions. The paunch here presents two swollen regions, resulting from a raising of the lining into folds, so arranged as to bound some 800 good-sized storage-cells for water. The opening into each of these can be closed by the action of a ring-muscle with which it is provided. It may be noted in passing that Camels possess upper front teeth, and that the manyplies is represented by a simple tube.

The Hippopotamus, among non-ruminating Artiodactyles, is a voracious plant-eating form, contrasting in this respect with its omnivorous allies the Pigs. Some noteworthy features of the common kind (*Hippopotamus amphibius*) may be enumerated. The formidable tusk-like incisors and canines grow continuously throughout the life of the animal, and are forwardly directed, the latter being kept sharp by natural wear (see vol. i, p. 108). The arrangement is adapted for digging up water-plants and shearing off vast quantities of all sorts of vegetation. Once within the mouth the food is chewed by large cheek-teeth, the broad crowns of which wear into a characteristic double-trefoil pattern. The huge stomach (11 feet long) is four-pouched, and the intestine may be 180 feet long. Such a digestive tube is clearly suited to deal with an immense bulk of food.

ELEPHANTS (PROBOSCIDEA)

Elephants (see vol. i, p. 103) present a number of interesting adaptations to the herbivorous habit. Prehension is here the function of an immensely elongated nose or *proboscis*, which is a sort of exaggerated edition of the Tapir's snout. The muscle of which it is mainly composed is arranged in a very complicated manner, enabling all sorts of elaborate curving movements to be performed. A greater range of possibilities is here presented than in the Giraffe, for though in that animal the long neck enables leaves and shoots at a considerable height from the ground to be reached, grazing on the ground is rendered more difficult, and can only be effected by straddling out the long fore-legs in a particularly ungraceful attitude. The trunk of the Elephant,

on the contrary, can secure with equal ease foliage placed far above the mouth or tufts of grass and the like situated far below it, and it can also be used in the uprooting of small trees, should the upper parts of these take the fancy of its possessor. The tip of the proboscis is extremely sensitive, and so shaped as to be capable of comparatively difficult manipulations. The shape, however, is different in the two existing species, that of the Indian form (*Euelephas*) having a finger-like prolongation. Elephants are further distinguished by remarkable peculiarities in their teeth. Incisors are entirely absent, except two in the upper jaw, which form the offensive and defensive weapons known as tusks. There are no canines, and the cheek-teeth are enormous

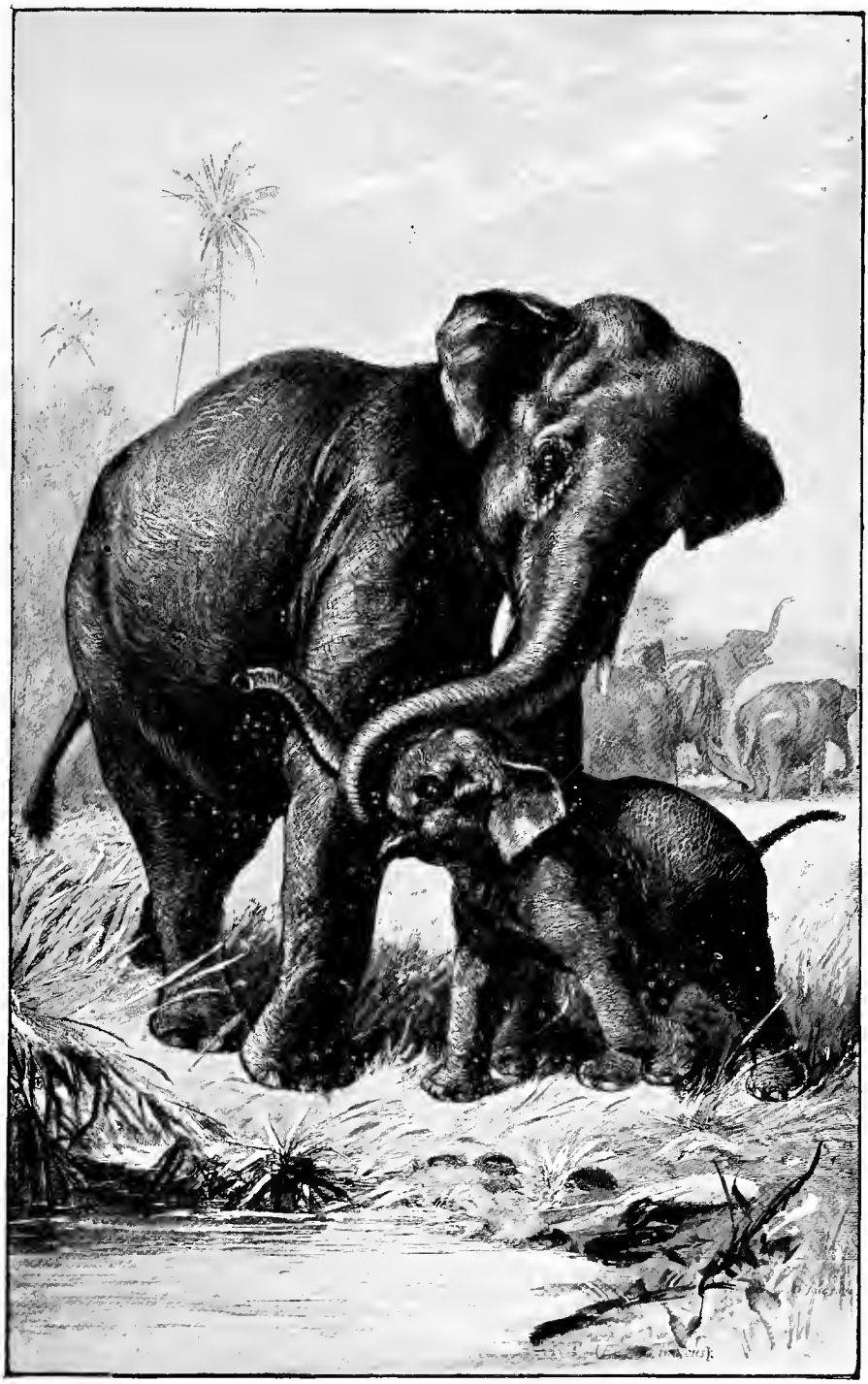


Fig. 420.—Grinders of African (A) and Indian (B) Elephants

grinders with broad crushing crowns (fig. 420). These succeed one another from behind forward, quite unlike what happens in ordinary Mammals, and so large are they that, at most, parts of two are in use at the same time on either side of the jaw. There is also a complex folding, reminding one of what has been described for Ruminants. It may be understood by supposing the tooth to be thrown into a number of transverse folds with deep valleys between them, each fold consisting of hard dentine covered by still harder enamel, while the valleys are filled by comparatively soft cement resembling bone in nature. On looking at the crown of a worn tooth of the African Elephant (*Loxodon*), the folds are seen to be comparatively few and somewhat lozenge-shaped, while in the Indian species they are much more numerous, relatively narrow, and somewhat wavy. It should further be noted that an elephant's grinder rises into position obliquely, so that the hinder folds are not at first brought into wear. The *stomach* is simple, but adaptations to vegetable food are present in the form of a large broad *cæcum*, while the intestines reach the length of from 106 to 125 feet, or to put it graphically, the intestines of three elephants, stretched out and placed end to end, would considerably more than suffice to mark out a course for a 100-yards race.

THE INDIAN ELEPHANT (*Euelephas Indicus*)

Elephants, the largest land animals now existing, are represented by two distinct kinds, the African Elephant (*Loxodon Africanus*) and Indian Elephant (*Euelephas Indicus*), native respectively to Africa and South Asia. These animals are adapted by their structure to vegetable food, which is secured by the prehensile trunk, this enabling them to seize food from the ground or from high above their heads with equal ease. Of front teeth only two upper incisors are present, which constitute the familiar tusks, serving as formidable defensive weapons. In adult elephants not more than four large and complicated grinding-teeth are in place at the same time. These consist of three sorts of material of different degrees of hardness, and thus always present an effective ridged crown for breaking up the food. The ridges are much narrower and more numerous in the Indian than in the African species. The stomach is simple, but the intestines are of great length, in correlation with the nature of the food, which is more difficult to digest and absorb than the flesh diet of carnivorous animals.



THE INDIAN ELEPHANT (EUELEPHAS INDICUS)

DRAWN FROM THE LIFE BY F. SPECHT

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SEA-COWS (SIRENIA)

Sea-Cows are herbivorous mammals which have taken to an aquatic life, feeding along the shore and, in one species, travelling up rivers for a considerable distance. Only two forms now exist—the Manatee and Dugong.

The Manatee (*Manatus*) (see vol. i, p. 101) is found on both coasts of the tropical parts of the Atlantic, and lives for the most part in the larger rivers, which it may ascend for hundreds of miles. Only fore-limbs are present, and though these help to some extent in seizing food, the chief prehensile organ is the upper lip, which is well developed and of remarkable shape. Deeply excavated in the middle, it possesses a sort of pad on each side, and the two pads can be brought together for the purpose of grasping food, which is held fast by their bristly surfaces, and then drawn back into the mouth. Canine teeth are entirely absent, and the adult possesses no incisors, though in the young animal vestiges of these are to be found under the thick *horny plates* with which the front of the jaws is armed. The roof of the mouth is furnished with similar plates. The *cheek-teeth* are in the form of grinders, with broad, square crowns marked by transverse ridges. Of these teeth 44 in all are developed, but not more than 24 of these are as a rule in use at once, for by the time the hinder ones are in place those in front of them have dropped out.

The Dugong (*Halicore*) (fig. 421) is essentially a marine animal, ranging round the shores of the Indian Ocean to the coast of Australia. The upper lip is not specialized for prehension as in the Manatee, but the lower lip is relatively larger and much swollen. One marked peculiarity is found in the front parts of the jaws, these being bent abruptly downwards. As before, they are armed with crushing *horny plates*. Incisors are better developed than in the Manatee, for two are present in the male in the form of long sharp *tusks*. These are developed within the jaw of the female, but never cut the gum. The remaining teeth are simple rounded *molars* with flat, smooth, rounded crowns. Not more than twenty are present at any time, and they appear to be degenerating structures, as shown by the absence of enamel. It is interesting in this connection to observe that a large toothless Sirenian, Rhytina, inhabited the coasts of the

Behring Sea until 1768, when it became extinct, having been exterminated for the sake of its flesh. The horny plates present in Manatees and Dugongs were here of greater extent, to compensate for the complete absence of teeth.

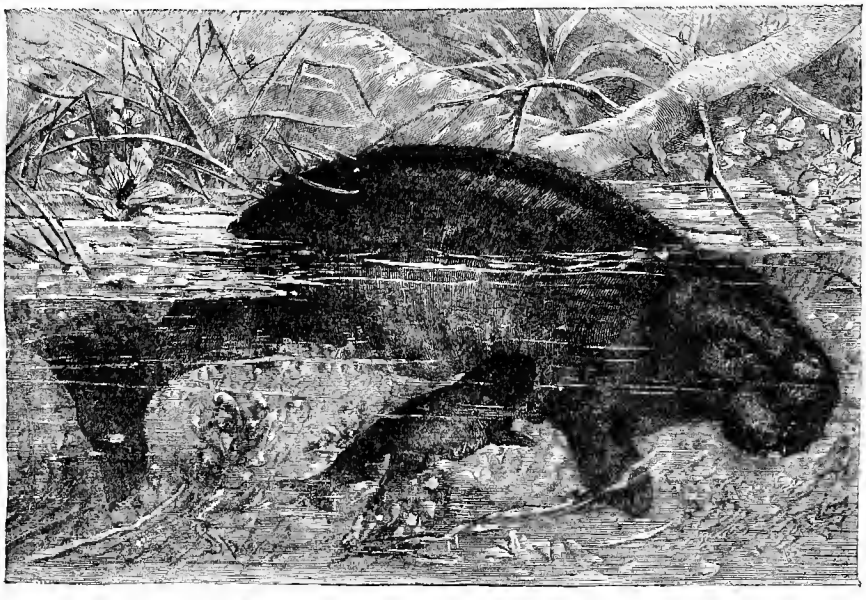


Fig. 421.—The Dugong (*Halicore dugong*)

GNAWING MAMMALS (RODENTS)

Rodents include a vast number of widely-distributed small animals, of which the great majority feed entirely on vegetable food. A Rabbit (*Lepus cuniculus*) or Hare (*L. timidus*) (fig. 422), illustrates very well the adaptations to a vegetable diet exhibited by the members of the order. Comparatively few teeth (twenty-eight) are present, the limited number being accounted for by the entire absence of canines and reduction of incisors. All the teeth grow continuously throughout life, in correspondence with which peculiarity they do not narrow into "fangs" within the substance of the jaws, but are of uniform thickness throughout. Two long chisel-edged *incisors* are present in the front of each jaw, and it is these which constitute the gnawing structures characteristic of the entire order. We have seen how the complex grinding-teeth of Ruminants, &c., are kept rough by being made up of materials of different degrees of hardness; this is a case where

a sharp edge is maintained by similar means, for the front side of each incisor is covered with a thick coat of hard enamel, at the back of which comes a softer mass of dentine. Hence the effect of wear is to produce and maintain a bevelled or chisel-like edge. As these teeth are continually growing it is necessary that they should be kept worn down by constant use, and should a rodent be so unfortunate as to lose one of its front teeth, its

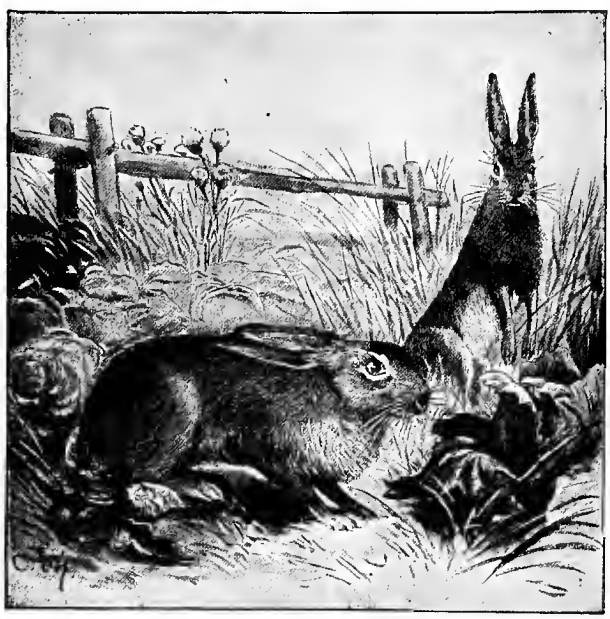


Fig. 422.—Hares (*Lepus timidus*)

fellow will have nothing to do to wear it down, and, continuing to grow, will first prove a hindrance to feeding, and then stop it altogether, sometimes even piercing the skull of its owner. The same thing happens (fig. 423) if these teeth are misplaced. In Rabbits, Hares, and their immediate allies, but not in remaining Rodents, two very small *reduced* incisors are present behind the large ones, but it is doubtful if these are of much use, and they may be looked upon as structures which are on the downward path of degeneration. The Rabbit's *cheek-teeth* are prismatic in form, and their broad grinding crowns are crossed by enamel ridges which, as in many other cases, slant differently above and below, so that when the upper and lower teeth are brought together the opposed ridges cross one another. A further adaptation to the plant-eating habit is found in the

shape of the projections (condyles) by which the lower jaw is united to the skull. These are elongated from before backwards, which permits of a movement in the same direction (see vol. i, p. 28). We may further note the great length of the digestive tube, fifteen or sixteen times that of the body, and further, though the *stomach* is simple, there is a very large and complex *cæcum* at the beginning of the large intestine. The *salivary glands*

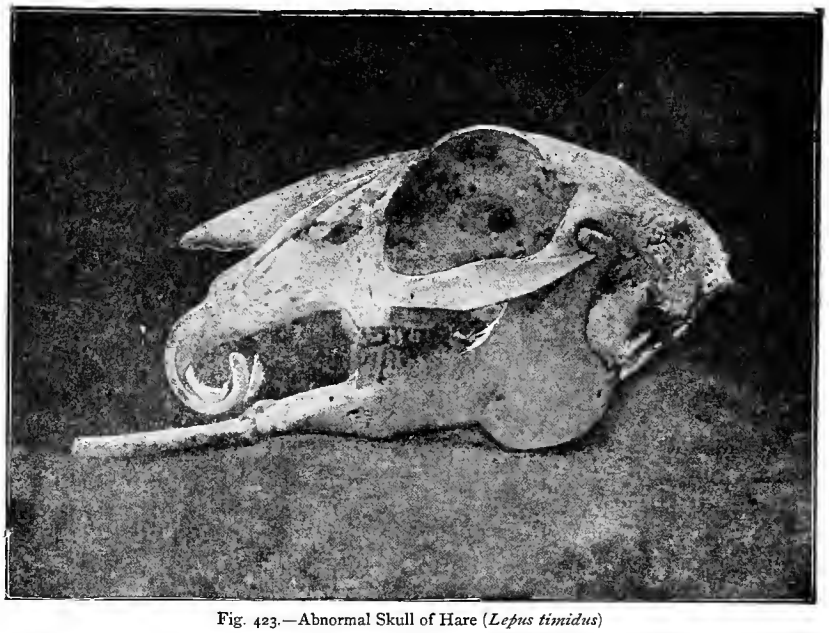


Fig. 423.—Abnormal Skull of Hare (*Lepus timidus*)

are extremely well developed, the secretion of these acting upon the abundant starch present in the food.

Dormice and Squirrels. — The structure of the Rodentia is on the whole so uniform that it would be tedious to review them in detail, and it will perhaps be enough to indicate a few points of special interest. We may, for example, note that while hares and rabbits feed on the surface of the ground, Dormice (*Myoxidæ*) and many Squirrels (*Sciuridæ*) are of arboreal habit, this being, as we have seen in many other cases, a favourite device for extending the range of feeding operations. It may, indeed, be taken as a general principle, that where food is to be found there will also be found animals provided with special means of getting at it. In these climbing forms, too, the *fore-paws* are used for holding the food, despite the fact

that the thumb is much reduced in size. The *cheek-teeth* are possessed of roots, and though both squirrels and dormice are mainly vegetarian, they also raid birds'-nests for the sake of the eggs and young.

Beavers (*Castoridæ*) deserve mention as regards their food, which consists of roots, bark, and young wood. They can even cut down trees by means of their immensely strong *incisors*, and do a great deal of damage in this way. Their *cheek-teeth* are more complex than in the forms so far mentioned, being better provided with enamel folds.

True Rats and Mice (*Muridæ*) are omnivorous in habit, but many of their immediate allies are herbivorous. This is the case, for example, with the mouse-like Field-Voles (*Arvicola*), which sometimes play havoc with growing crops, even destroying their roots by burrowing,—as also with the larger Hamsters (*Cricetus*) and Lemmings (*Myodes*). Hamsters are among those rodents possessed of *cheek-qouches*, serving for temporary storage of food, and in this case particularly large.

A very interesting family is that of the Mole-Rats (*Spalacidæ*), of which a typical representative is the Great Mole-Rat

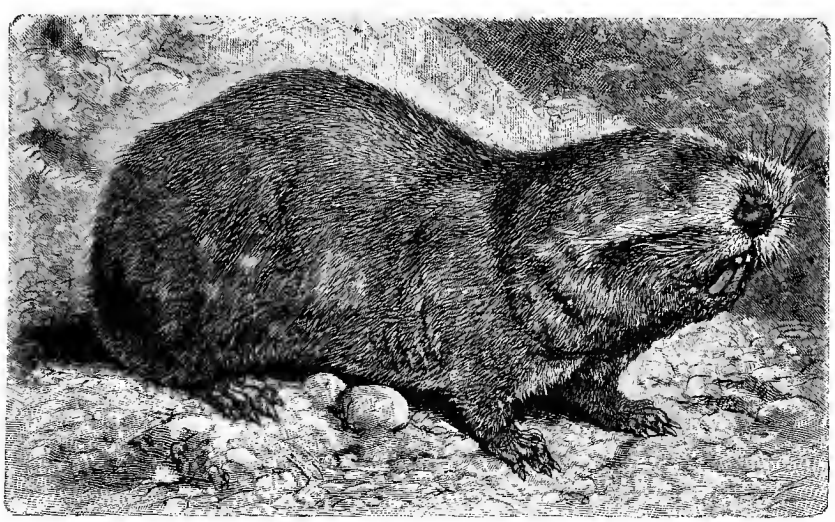


Fig. 424.—The Common European Mole-Rat (*Spalax typhlus*)

(*Spalax typhlus*) (fig. 424) of South-east Europe, South-west Asia, and Egypt. It has elsewhere been pointed out that adaptation to a particular mode of life results in corresponding specialization

in shape and structure. Thus, in Mammals, thorough-going underground forms present more or less the features which are familiarly embodied in the common mole. The body is compact, the neck ill-marked, the tail reduced, and the limbs short and strong. And further, the eyes and external ears are the reverse of prominent, while the fur is short, thick, and velvety, affording little resistance to the passage of the animal along its burrow whether it moves forwards or backwards. All these characters are presented by the Great Mole-Rat, and the much-reduced eyes are in this case actually covered by a layer of skin. The food consists of roots, bulbs, and the like.

Porcupines (*Hystricomorpha*) are mostly thick-set forms, distinguished by the development of a more or less complete array of defensive *quills*, and with their *cheek-teeth* presenting grinding crowns marked by folds of enamel. The species belonging to the Old World live upon the ground, while those of the New World are arboreal, and those of South America have prehensile tails.

Among the Cavy or Guinea-Pig Family (*Caviidæ*), all confined to South America, the Capybara (*Hydrochærus capybara*) may be mentioned as a very interesting type. It is the largest living rodent, reaching the size of a small pig, and is of aquatic habit, as might be suspected from the presence of short *webs* between the toes of both fore- and hind-feet. But its most interesting peculiarity is found in the structure of the *cheek-teeth*, which have grinding crowns of far more complex nature than those of other rodents, this being especially well-marked in the case of the last members of the series, which resemble on a small scale the grinders of an elephant.

EDENTATES (Edentata)

Among the archaic order of Edentates the Sloths of the South American forests are purely herbivorous, feeding upon the leaves, shoots, and fruits of the trees among which they live, suspended upside down by means of long curved claws. Their dull colour renders them inconspicuous, and the resemblance to surroundings is increased by the presence of a minute alga which grows on the stiff hairs, and imparts a greenish hue. The neck is very flexible, especially in the Three-toed Sloth (*Bradypus*) (fig. 425), which possesses nine neck-vertebræ as against the

almost invariable number of seven, characteristic of Mammals generally, and this flexibility must be of use in enabling the animal to reach a large number of leaves without altering the position of its body. The long mobile *tongue* is used in prehension, and is not unlike the same organ in the related Ant-Eaters, though they, as we have seen, use it in a very different way. As might be anticipated, the *teeth* are specialized in accordance with the nature of the food, incisors and canines being entirely absent, while the cheek-teeth,

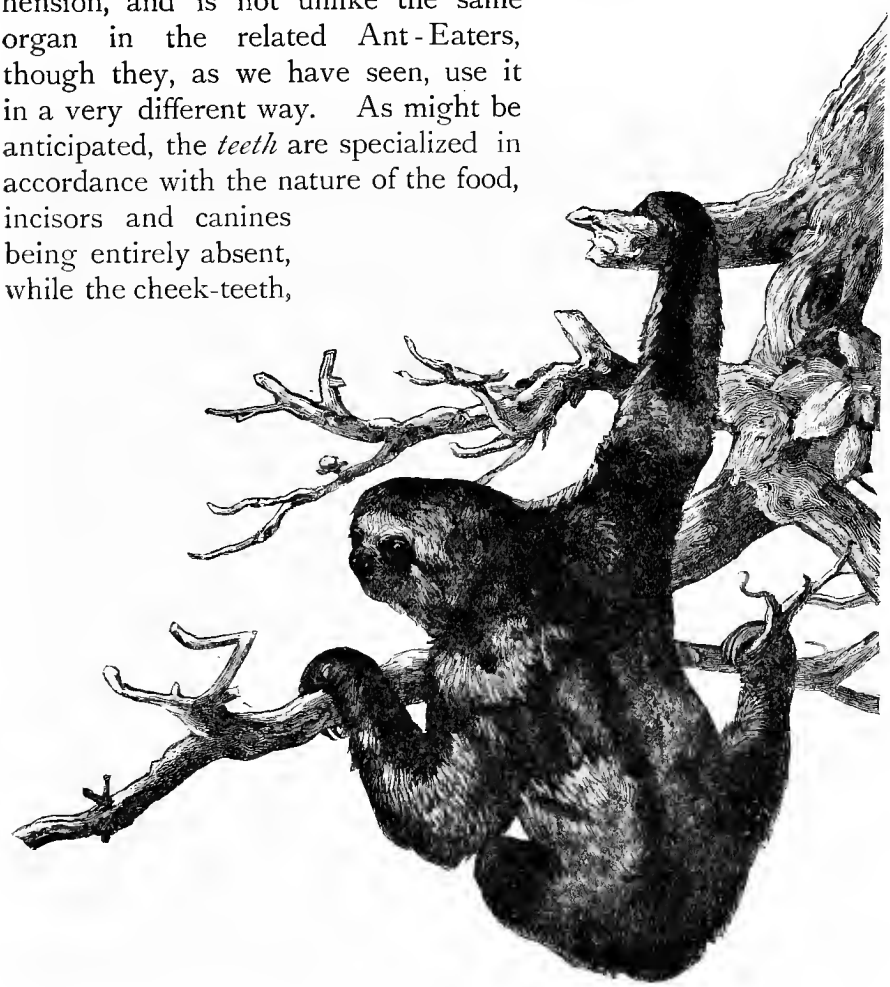


Fig. 425.—Three-toed Sloth (*Bradypus tridactylus*)

of which five are present on each side above and four on each side below, are all or mostly of the nature of blunt-crowned grinders, consisting of dentine covered by a thick coating of enamel. The qualification as to form is rendered necessary by the fact that in the Two-toed Sloth (*Cholæpus*) the first cheek-tooth on either side of each jaw is tusk-shaped. The teeth so

specialized work against one another like scissors, and are kept sharp by mutual wear. A further adaptation to plant-food is found in the complex nature of the stomach, which recalls what has been described for other cases.

POUCHED MAMMALS (MARSUPIALS)

Marsupials, as represented by the forms living in the Australian region, to which the large majority of existing species are confined, have already been instanced as an interesting order



Fig. 426.—The Koala (*Phascolarctos cinereus*)

which, in the absence of competing mammals of higher structure, have become specialized in various directions so as to fit them for food of all kinds, some species playing the part of carnivores, others of insectivores, and so on. A similar wide range of adaptations is found among the plant-eating forms of this order, and these may conveniently be described as making up three sections, including respectively fruit-eating, herbivorous, and root-eating marsupials.

FRUIT-EATING MARSUPIALS include the Phalangers (*Phalangistidæ*), climbing forms known as "opossums" to the colonists,

though quite distinct from the true Opossums of America. There are numerous species, some small, others moderately large, with thick soft fur, and in most cases a bushy tail, which may give a squirrel-like appearance to those of lesser size. Both *fore-* and *hind-paws* are adapted to climbing, the thumb or great toe, as the case may be, possessing the power of opposing itself to the other digits. In some cases the long tail is grasping or prehensile and of material aid in progression among trees. The cheek-teeth are grinders with broad-ridged crowns, and the canines are not usually prominent. A somewhat aberrant member of the group is the Koala (*Phascolarctos*) (fig. 426), a clumsy-looking tailless form, the appearance of which has earned for it the name of "native bear". The *fore-paws* are here specialized as grasping organs by an arrangement which has been compared to that found among Chameleons (see p. 74). The thumb and first finger are bound up together by skin, and are jointly opposable to the other digits. The middle *incisors* above and below resemble those of rodents, and are much larger than the rest of the front teeth, and, among the *cheek-teeth*, the hinder series or molars possess broad crowns studded with blunt tubercles.

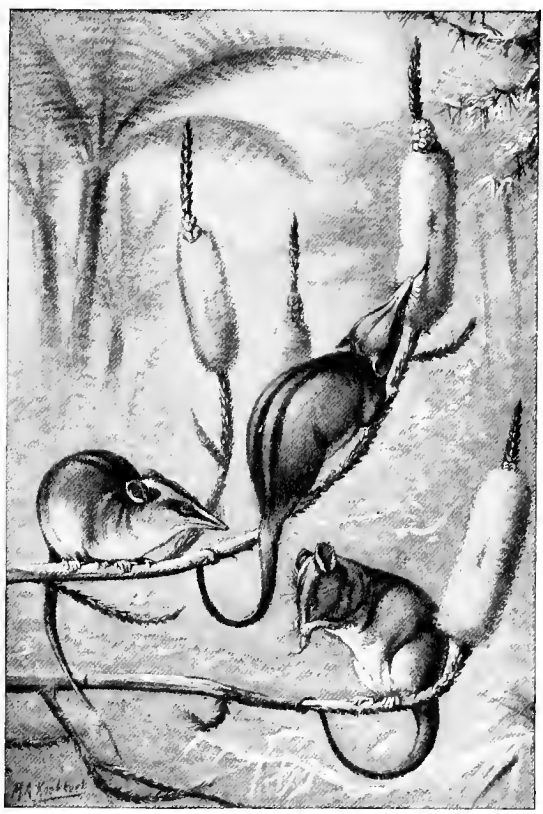


Fig. 427.—The Long-snouted Phalanger (*Tarsipes rostratus*)

One of the most interesting members of this family is the Long-snouted Phalanger (*Tarsipes rostratus*) (fig. 427) of Western Australia, a diminutive tree-inhabiting creature which feeds at night. It looks something like a mouse with a long nose, and

possesses a long prehensile tail. The food is said to consist mainly of nectar, and this is extracted from the recesses of flowers by means of a long, slender tongue, which can be protruded from the unusually small mouth for a considerable distance. An adaptation of this kind could only have arisen in a country like Australia, where numerous plants possessing nectar-yielding flowers are to be found blossoming at all seasons. It is extremely probable that the minute insects which are often found lurking in or near the nectar-producing parts of flowers also constitute a part of this animal's food.

The HERBIVOROUS MARSUPIALS embrace the Kangaroos (*Macropodidæ*), which present a considerable range in size, structure, and habit. One common feature is the greater development of the *hind-limbs*, which, together with the strong *tail*, are used to support the body as a camera is supported by its tripod, and in this way the strongly-clawed five-fingered fore-limbs are liberated for use as hands, acting as very efficient prehensile organs. Three pairs of cutting *incisors* are imbedded in the front of the upper jaw, and opposed to these below is a single pair of relatively huge front teeth growing straight forwards. *Canines* are absent or only feebly represented by a small upper pair, and there are in all twenty *cheek-teeth*, in the form of grinders with crowns adapted for crushing. The *stomach* is folded in a complex way, as often happens in plant-eating mammals. A series showing increasing specialization as regards teeth, and disproportion between fore- and hind-limbs, is presented by the Tree-Kangaroos, Rat-Kangaroos, Rock Kangaroos, and the forms with which the name of the group is most commonly associated. Tree-Kangaroos (*Dendrolagus*) are small arboreal species inhabiting New Guinea, and at first sight are so little specialized that an ordinary observer would scarcely think their name justifiable. The remaining members of the series are characteristic of the Australian continent, and do not climb trees, though the Rock-Kangaroo is an expert climber among rocks. Rat-Kangaroos (*Hypsiprymnus*) are small springing forms living mostly on grass-land, and sometimes burrowing to obtain the succulent underground parts of certain plants. Rock-Kangaroos (*Petrogale*) look like small kangaroos of the ordinary sort, these latter including the larger forms (*Macropus*), which are the most specialized members of the group, and are commonly seen in captivity in the Zoo.

ROOT-EATING MARSUPIALS include the clumsy-looking Wombats (*Phascolomyidæ*) of Australia and Tasmania, which possess short, stout limbs provided with sharp, strong claws well suited for burrowing. Plantigrade as to the hind-limbs, and badly off in the matter of tail, they irresistibly suggest small bears in their

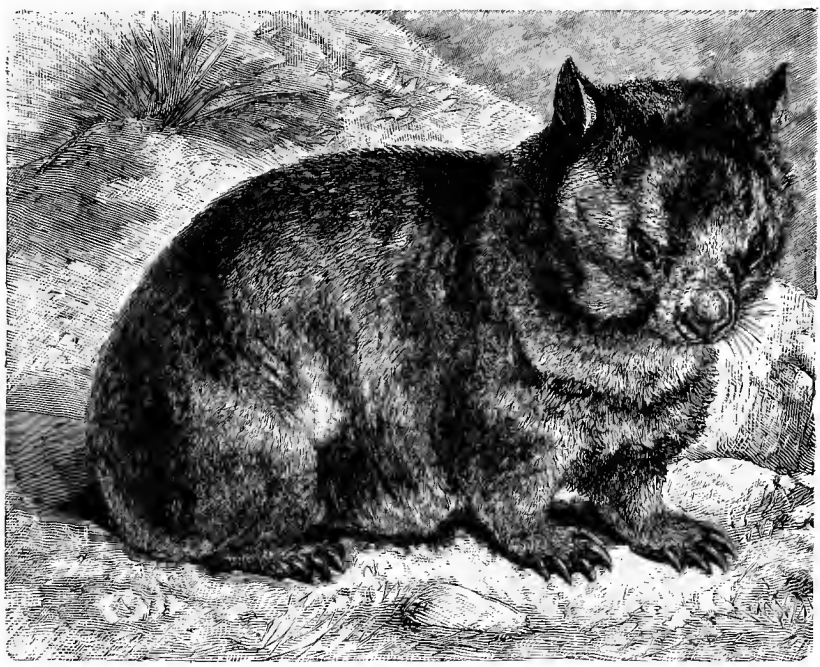


Fig. 428.—The Wombat (*Phascolomys wombat*)

appearance (fig. 428). Their food embraces roots as well as grass and the like, and they are nocturnal in habit, remaining during the day either in dark corners or in burrows they have made. The teeth of a wombat present interesting analogies to those of rodents, no doubt as the result of adaptation to gnawing habits. All of them grow continuously throughout life so as to compensate for wear. Of *incisors* but four are present, shaped like those of a rabbit, and kept bevelled to a chisel-edge owing to the fact that they are only covered by hard enamel in front, which wears much more slowly than the softer dentine behind it. Canines are entirely absent, and the remainder of the dentition is made up of twenty *cheek-teeth*, five on each side of either jaw.

CHAPTER XVI

THE FOOD OF ANIMALS—PLANT-EATING BIRDS, REPTILES, AMPHIBIANS, AND FISHES

BIRDS

The digestive organs of the Pigeon (*Columba livia*), a typical vegetarian bird, have already been described in detail (vol. i, pp. 139–152), so that it is only necessary here to recapitulate some of the leading features. The pointed conical *beak* serves for prehension, and the absence of teeth is made up for by conversion of part of the stomach into a muscular *gizzard* (fig. 429) with a horny lining, the masticatory action being enhanced by small stones swallowed from time to time. The lower part of the gullet is dilated into a capacious *crop*, which serves for the temporary storage of food. It may further be noted that in accordance with the nature of the food the digestive tract is of considerable length.

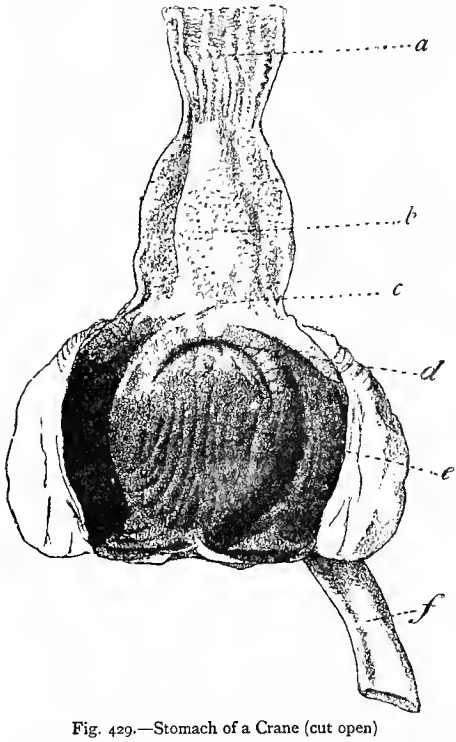


Fig. 429.—Stomach of a Crane (cut open)

a, Lower end of gullet; *b*, chemical stomach (proventriculus); *d*, opening from gizzard to small intestine; *e*, gizzard; *f*, beginning of small intestine.

A vast number of birds feed largely or mainly upon vegetable matter, but the specializations involved are often so slight that it would not be worth while to make an attempt to trace them, and the limited space available will therefore be

devoted to the description of a few of the more striking adaptations to special habits.

PIGEONS (COLUMBIDÆ)

The large and widely distributed family of Pigeons (*Columbidæ*) includes birds which are exceedingly voracious, and as, too, their food is bulky and difficult of digestion, it is not surprising to find that the *crop* is large and the *gizzard* powerful. A considerable number of species are collectively known as Ground-Pigeons, owing to their feeding habits. A typical example is the well-known Turtle-Dove (*Turtur communis*), which may frequently be seen levying toll upon such crops as yield grain or seeds. Here also may be mentioned the largest members of the family, the Crowned-Pigeons (see vol. i, p. 167) of the Australian region, described by Semon (in *In the Australian Bush*) in the following language:—"In New Guinea and the neighbouring districts we not only find the most brilliant, but also the largest and most peculiar of all pigeons, the Crown or Goura Pigeons, which attain the size of a goose, and are crowned by a fan-like erectile diadem. The handsomest head-gear of this sort is to be found in the great species *Megapelia* (*Goura*) *Victoriæ*, whose prettily-fringed feathery diadem is the loveliest head-gear ever worn by a bird. These crested pigeons are common in New Guinea. During daytime they are generally seen moving about the ground, where they feed on fruit dropped from the trees."

Those Pigeons which haunt wooded country are known broadly as Tree-Pigeons, and these may either feed mostly on seeds and grain, as in the case of the Wood-Pigeon (*Columba palumba*) and Stock-Dove (*C. ænas*) of Britain, or fruit may be the most important article of diet. Among the latter are those forms to which the name of "fruit-pigeon" in the limited sense is commonly applied. In many hot and tropical countries inexhaustible supplies of suitable food are to be found on many of the trees. Speaking of a Sumatran village, Forbes (in *A Naturalist's Wanderings in the Eastern Archipelago*) says:—"In its near vicinity grew one of the grandest *Urostigma* trees I have ever seen; its broad buttresses and sturdy supporters, among which a wanderer might almost lose himself, looking like the pillars of some ancient Moorish temple. It was thick in fruit, and harboured legions of skipping squirrels, great apes, and troops of

monkeys, which, to the eye surveying them from below, looked like pigmies flitting about among its branches. Immense flocks of the large fruit-pigeons, and of the smaller members of that numerous and beautiful family, crowded to this rendezvous, their wings keeping up a constant whirring in the air by their coming and going; scores of the Great Hornbill (*Buceros galeatus*), with their 5-foot expanse of wing; and myriads of smaller birds, whose varied calls and notes alone indicated their presence, flocked from far and near to this inexhaustible storehouse (and its produce could not be less than tens of thousands of bushels of figs), and yet the vast assemblage but sparsely populated this single magnificent specimen of the vegetable kingdom." Some of the large fruit-eating Pigeons are able to bolt fruits of considerable size, and to this end their long beaks are capable of great distension at the base. This is the case, for example, with the Nutmeg-Pigeons of South-east Asia, which swallow nutmegs whole, rejecting them again after the mace with which they are invested has been utilized.

TOUCANS (RHAMPHASTIDÆ)

An interesting adaptation to fruit-eating is found in the gaudily-coloured Toucans of South America, which possess immense beaks flattened from side to side. The use of this remarkable arrangement is suggested by Bates (in *The Naturalist on the Amazons*) in the following passage:—"Flowers and fruit on the crowns of the large trees of South American forests grow principally towards the end of slender twigs, which will not bear any considerable weight; all animals, therefore, which feed upon fruit, or on insects contained in flowers, must of course have some means of reaching the ends of the stalks from a distance. . . . The purpose of the enormous bill here becomes evident. It is to enable the Toucan to reach and devour fruit while remaining seated, and thus to counterbalance the disadvantage which its heavy body and gluttonous appetite would otherwise give it in the competition with allied groups of birds. The relation between the extraordinarily lengthened bill of the Toucan and its mode of devouring food is therefore precisely similar to that between the long neck and lips of the Giraffe and the mode of browsing of the animal. The bill of the Toucan can scarcely be considered a very perfectly-formed instrument for the end to

ARGENTINE TOUCANS (*Rhamphastus toco*)

The brilliantly coloured Toucans, of which one of the largest species (two feet in length) is figured, inhabit the dense forests of tropical America. They are gregarious in habit, and feed chiefly, though not entirely, on fruits and seeds. The short strong legs, with two toes directed forwards and two backwards (as in the closely allied woodpeckers), are well adapted to the perching habit. A much more remarkable feature is the huge laterally flattened beak, which enables these birds to reach their food with the minimum of exertion. That of the Argentine Toucan has been compared in shape and colour to the claw of a lobster. Although so large the beak is far from heavy, and does not hamper the flight, which is much more easy and rapid than might be anticipated.



ARGENTINE TOUCANS (RHAMPHASTUS TOCO)

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which it is applied, as here explained; but nature appears not to invent organs at once for the functions to which they are now adapted, but avails herself, here of one already-existing structure or instinct, there of another, according as they are handy when need for their further modification arises."

CROWS (CORVIDÆ)

The mere shape of a bird's beak is often a very imperfect indication of the nature of the food. Thus we have seen (p. 58) that in the Woodpeckers this organ is of powerful character, and shaped like a long straight cone, enabling the bird to cleave bark and wood in its search for insects. A very similar beak is found in the crow-like Nutcrackers (*Nucifraga*), but in this case it is used for breaking open hazel-nuts. The familiar British Nuthatch (*Sitta cæsia*), though insectivorous in summer, lives on nuts to a large extent in the winter, opening them by means of its strong pointed beak, as in the preceding case. In summer the beak is used in the same way and for the same purpose as that of a woodpecker.

FINCHES (FRINGILLIDÆ)

The small birds known as Finches feed mostly upon seeds and small fruits, and they possess short conical beaks of great strength, well suited to this kind of diet. Common British examples are the Greenfinch (*Ligurinus chloris*), Chaffinch (*Fringilla cœlebs*), Linnet (*Linaria cannabina*), House-Sparrow (*Passer domesticus*), and Tree-Sparrow (*P. montanus*). It must not be supposed, however, that birds of the Finch kind are exclusively vegetarian in habit, and it is interesting that the food may differ at different ages. It is, for example, well known that house-sparrows feed their young upon caterpillars and other insect larvæ, which are no doubt better suited to the youthful digestion than seeds or fruit. The Crossbills are interesting members of the Finch family which possess the unique peculiarity of having the two halves of the beak crossed over each other, as seen, for example, in the British species (*Loxia curvirostra*) (fig. 430), found in northern Scotland. These birds live in forests of pine or fir, and their curious beaks are admirably suited for the extraction of the seeds which are hidden between the woody scales of cones. This happens to be a good illustration of the biological truth that

highly specialized organs have been evolved from simpler structures, for nestling Crossbills still possess symmetrical beaks like

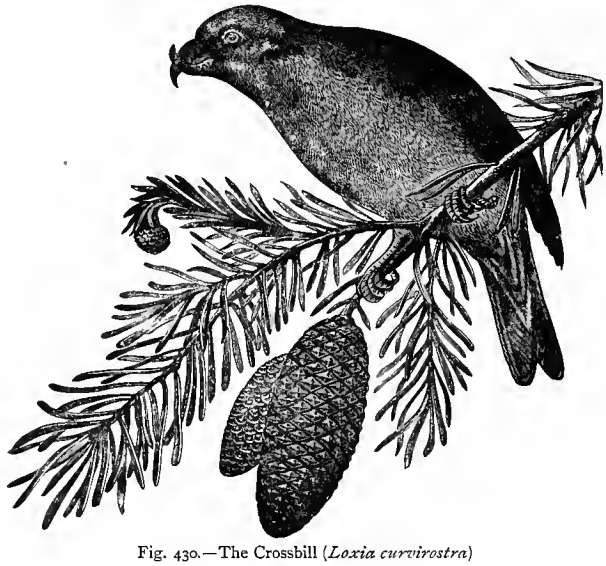


Fig. 430.—The Crossbill (*Loxia curvirostra*)

those of other birds, reminiscent, no doubt, of the ancestral condition.

OIL-BIRDS (STEATORNITHIDÆ)

We are apt to associate a markedly hooked beak with rapacious habits, but notable exceptions to the rule are afforded by Oil-Birds and Parrots. The Oil-Bird or Guacharo (*Steatornis Caripensis*) inhabits caves in the northern parts of South America, and possesses a strong hooked beak, mainly used, however, for securing the fruits of the nectandra-tree. This is another case of adaptation in a South American animal (see p. 86) for seizing berries or other fruit growing on the end of slender stalks incapable of supporting any considerable weight, and the Oil-Bird, which is about the size of a crow, feeds on these particular fruits when it is on the wing.

PARROTS (PSITTACI)

The large and interesting group of Parrots presents many interesting adaptations to the nature of the food, which chiefly consists of fruits, seeds, and other parts of plants. The shape of the curious hooked *beak* is familiar to everybody, but all may

not have noticed its chief peculiarity, which consists in the power of freely moving the upper half as well as the lower, an obviously useful arrangement. Even more useful is the power of holding the food in one of the climbing *feet*, while the bird stands upon the other. Parrots are social in habit as a general rule, and feed in flocks or companies. An example of this is the nocturnal flightless Owl-Parrot (*Stringops habroptilus*) of New Zealand, which comes out of its hiding-place at night to feed upon the ground, making with its companions broad tracks upon the vegetation a foot or more wide. Some members of the group dig for their food, of which a good instance is the Slight-billed Parraquet (*Hemicognathus leptorhynchus*) of Chili, the long and slender upper mandible of which is well suited for attacking grass-roots, as well as for extracting grain from the husk. But the most remarkable case of specialization is that of the Great Black Cockatoo (*Microglossus aterrimus*) (fig. 431) of North Australia and the New Guinea islands, a bird of the size of a large crow, with an enormous beak, but a small worm-like tongue with a horny tip. Semon (in *In the Australian Bush*) alludes to this species as "one of the largest parrots existing, and furnished with a bigger and stronger beak than any other. This beak enables the bird to open even the strong fruits of the kanary-tree. It serves it as saw and borer, and in the place of cutting nippers, while its tongue, which is horny at the end, is useful in removing the kernels or the flesh from the tapped or broken-up fruit." The use of the beak was worked out in detail by Wallace, who describes it (in *The Malay Archipelago*) as follows:—"The great black cockatoo frequents the lower parts of



Fig. 431.—Great Black Cockatoo (*Microglossus aterrimus*)

the forest, and is seen singly, or at most two or three together. It flies slowly and noiselessly and may be killed by a comparatively slight wound. It eats various fruits and seeds, but seems more particularly attached to the kernel of the kanary-nut, which grows on a lofty forest-tree (*Canarium commune*) abundant in the islands where this bird is found; and the manner in which it gets at these seeds shows a correlation of structure and habits which would point out the kanary as its special food. The shell of this nut is so excessively hard that only a heavy hammer will crack it; it is somewhat triangular, and the outside is quite smooth. The manner in which the bird opens these nuts is very curious. Taking one endways in its bill, and keeping it firm by a pressure of the tongue, it cuts a transverse notch by a lateral sawing motion of

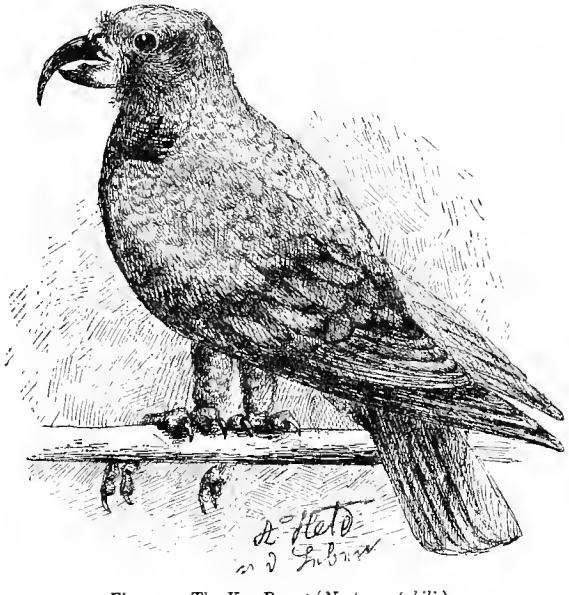


Fig. 432.—The Kea Parrot (*Nestor notabilis*)

the sharp-edged lower mandible. This done, it takes hold of the nut with its foot, and, biting off a piece of leaf, retains it in the deep notch of the upper mandible, and again seizing the nut, which is prevented from slipping by the elastic tissue of the leaf, fixes the edge of the lower mandible in the notch, and by a powerful nip breaks off a piece of the shell. Again taking the nut in its claws, it inserts the very long and sharp point of the bill and picks out the kernel, which is seized hold of, morsel by morsel, by the

extensile tongue. Thus every detail in form and structure in the extraordinary bill of this bird seems to have its use, and we may easily conceive that the black cockatoos have maintained themselves in competition with their more active and more numerous white allies by their power of existing on a kind of food which no other bird is able to extract from its stony shell."

Birds accredited with the habit of feeding on honey are probably in most cases, *e.g.* in Honey-Guides (*Indicatoridæ*) (p. 63) and Humming-Birds (*Trochilidæ*), attracted by the minute insects often associated with nectar; but there are certain cases where the honey itself is undoubtedly the main object for which flowers are visited. A good example of this is offered by some of the parrots, in which the tongue is frayed out into a sort of brush, eminently suited for licking up honey. Among these are the Kea (fig. 432) and Ka-ka parrots of New Zealand (*Nestor notabilis* and *N. meridionalis*), and the Lories and Loriquets of the Australian region. Among the latter is the Blue-mountain Parrot (*Trichoglossus chlorolepidotus*) of Australia, which has been watched sucking the honey from the flowers of eucalyptus.

REPTILES

Reptiles are for the most part carnivorous in habit, Crocodilians and Snakes being exclusively so, but there are some few Chelonians and Lizards which subsist upon vegetable food. In the former group it is clear that the firm horny sheaths with which the toothless jaws are encased are as well suited for dividing plants as the beaks of vegetarian birds. The marine turtles are nearly all predaceous, but the famous Green Turtle (*Chelone midas*) (see vol. i, p. 219) of aldermannic reputation feeds upon brown sea-weeds, grazing upon such of these as are completely submerged. The beak does not possess the sharply-hooked tip characteristic of many of its carnivorous allies, such, for example, as the Hawk's-bill Turtle (*C. imbricata*), which derives its name from the circumstance (see fig. 58).

All terrestrial tortoises, including some two-score species of the genus Testudo, are vegetarians, as, for example, the well-known Grecian Tortoise (*Testudo Græca*) (see vol. i, p. 213), so commonly seen in captivity. Here, too, are included those Giant Tortoises which either now exist, or within historic times have

existed, upon islands of the Indian Ocean and East Pacific. Regarding the food of those found in the Galapagos Islands, Darwin (in *A Naturalist's Voyage*) speaks as follows:—"The tortoises which live on those islands where there is no water, or in the lower and arid parts of the others, feed chiefly on the succulent cactus. Those which frequent the higher and damp regions eat the leaves of various trees, a kind of berry, which is acid and austere, and likewise a pale-green filamentous lichen, that hangs in tresses from the boughs of the trees."

Among the few Lizards which live upon plant food are the true Iguanas and two interesting species from the Galapagos Islands. The Common Iguana (*Iguana tuberculata*) of tropical America is a large lizard of arboreal habit, which lives chiefly upon leaves and fruit. The front teeth are simply conical, but the crowns of the others are flattened from side to side, and have saw-like edges. The upper and lower teeth work against one another in such a way as to effectively masticate the food. A West Indian ally of this form is depicted in fig. 433.

The two plant-eating lizards of the Galapagos Islands are both of large size, and all their teeth are laterally flattened, while each is provided with three little projections from the crown. Though simpler in nature than the serrated teeth of the Iguanas, they work against one another in much the same way and for a similar object. Of these two lizards one is the only marine representative of its order and is appropriately called the Sea-Lizard (*Amblyrhynchus cristatus*). It is able to remain for a considerable time under water, and numbers of these lizards browse in company upon submerged sea-weeds. The Galapagos Land-Lizard (*Conolophus subcristatus*) is a burrowing form, and lives upon cactus-branches and the leaves of acacias and other trees.

AMPHIBIANS

An example has already been given (p. 187) of birds which when still in the nest are fed on animal food, becoming plant-eaters when adult. Amphibians illustrate the converse of this, for while the adults are invariably carnivorous, the larvæ or "tadpoles" (fig. 434) are herbivorous. The common Frog (*Rana temporaria*) will serve as an example, and in this creature we find the jaws of the tadpole provided with firm horny beaks,

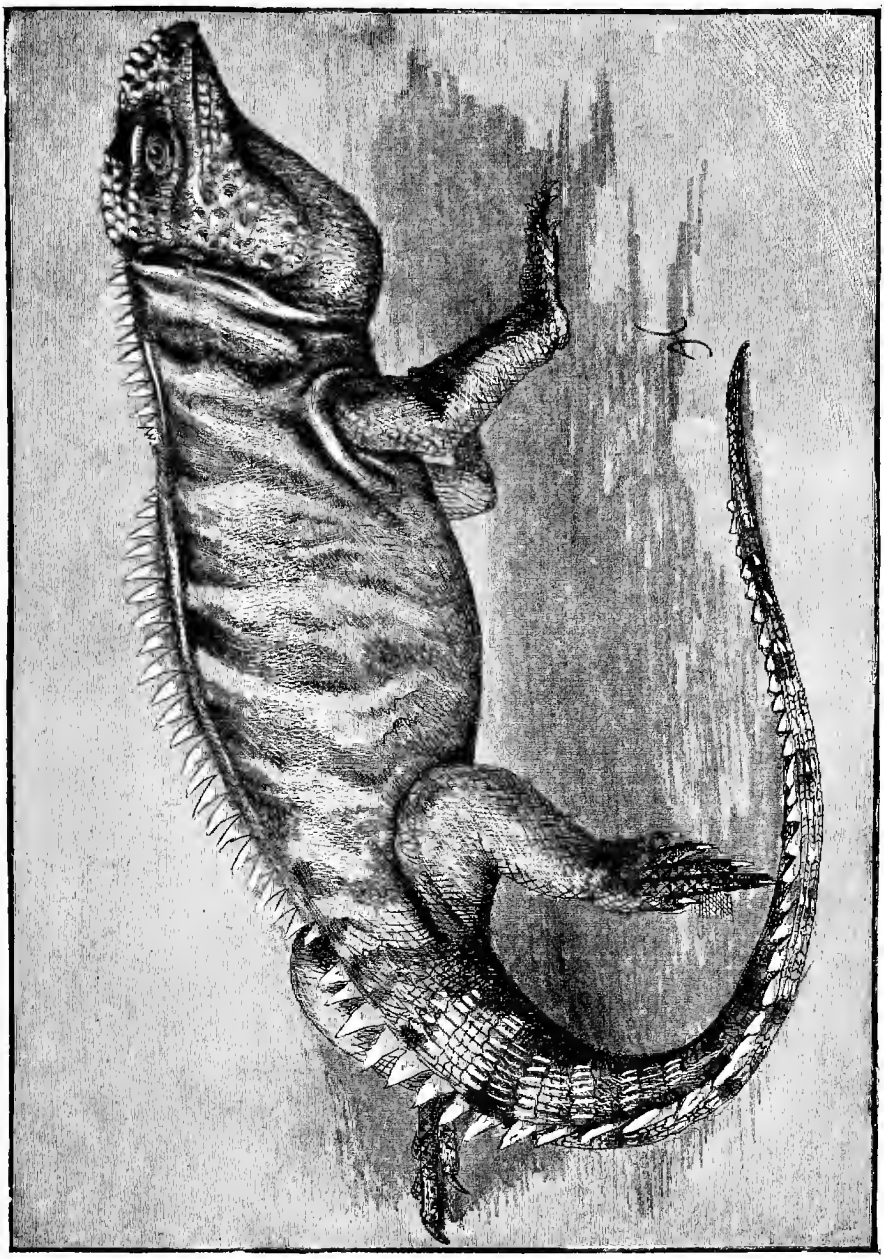


Fig. 433.—West Indian Ring-tailed Iguana (*Cyclura carinata*), about ¼ natural size

by means of which it can browse upon delicate algæ, which are found floating in slimy green masses in its native pond or ditch. Later on, these beaks are cast off, and at the same time the little pointed teeth characteristic of the adult frog are developed.

It has already been pointed out (p. 7) as a rule of general application that the digestive tract is relatively longer in creatures which live on vegetable food than in those which subsist on



Fig. 434.—Tadpoles

animal matter. The Frog is a very interesting application of this rule, for we find that in the tadpole the intestine, here coiled like a watch-spring, is relatively longer than in the adult animal.

FISHES

Lung-Fishes (Dipnoi), Sharks and Rays (Elasmobranchii), and the Ganoid group (Sturgeons, &c.) of the Teleostome fishes are exclusively or mainly carnivorous, and the same is true for most families of the Ordinary Bony-Fishes (Teleostei) which constitute the great bulk of the last-named subdivision. A good many of the Teleosts, however, are mixed feeders, and a few are vegetarians pure and simple. Among these last may be mentioned

some of the Sea-Breams (*Sparidæ*) and a few species of Carp (*Cyprinidæ*).

Certain Sea-Breams (species of *Haplodactylus*), which inhabit the cooler parts of the South Pacific, live upon sea-weed, and their jaws possess flattened teeth armed with projecting points, capable of dealing with this sort of food.

The Beaked Carps (species of *Chondrostina*), that live in some of the rivers of Europe and Western Asia, browse upon the green thread-like algæ which grow on stones, and the edge of the lower jaw in these fishes is provided with a sharp cutting edge, well adapted for mowing down this slippery vegetable growth.

CHAPTER XVII

THE FOOD OF ANIMALS—PLANT-EATING MOLLUSCS

The class of Cephalopoda, including Cuttle-Fishes and their allies, contains no vegetarian forms, and since the Tusk-shells (Scaphopoda) and bivalve molluscs (Lamellibranchia) affect a mixed diet, they will be noticed in a later chapter. The great class of GASTROPODA, however, including Snails and Slugs in the broadest sense of the words, embraces a large number of forms which live exclusively upon vegetable food, Periwinkle, Limpet, and Garden-Snail being familiar examples. As previously noted (see p. 96) the *shells* of such forms are distinguished by the fact that their opening or mouth has a continuous outline and is not

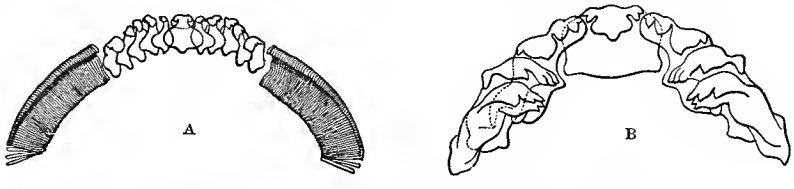


Fig. 435.—Single Rows of Teeth from radulæ of Plant-eating Sea-Snails (greatly enlarged)
A, Trochus. B, Periwinkle (*Littorina*)

interrupted by a notch for the reception of a breathing tube. There are also a number of characteristic features about the soft parts of vegetable-feeding gastropods. The *mouth* is not placed at the end of a proboscis capable of being either protruded or drawn back into the body, as is the case in many carnivorous species, but either opens directly on the rounded front end of the head, or upon a short blunt snout. The *rasping organ* (odontophore) projecting from the floor of the mouth is provided with a horny ribbon (radula) that is often of great length, and instead of being studded by comparatively few and specialized teeth (see p. 96) is provided with a very large number of simple bluntish ones (fig. 435). We also find additional hard parts in the form of one or more horny *jaws* projecting from the roof

of the mouth. It must, of course, be clearly understood that the words "jaws" and "teeth", as applied to the biting organs of snails, only refer to their use, and are not meant to suggest equivalence to the similarly-named parts of back-boned animals.

Limpets.—It would be tedious to describe in detail the feeding habits of many plant-eating molluscs, and it will probably be sufficient for the present purpose to illustrate the matter by a

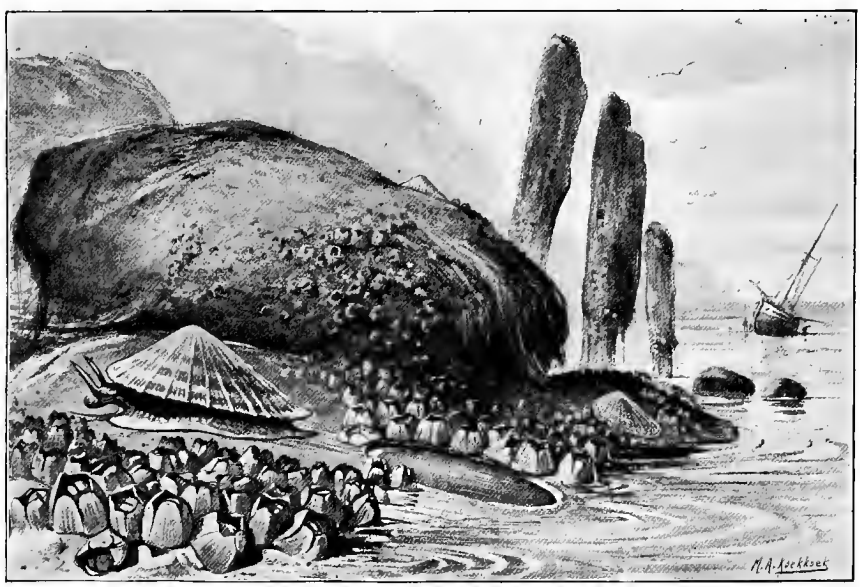


Fig. 436.—A Limpet (*Patella vulgata*) leaving its scar at ebb-tide

few examples. The Common Limpet (*Patella vulgata*) (fig. 436) abounds on rocks between tide-marks all round our coasts, living on a depressed spot, or "scar", worn out in the hard stone, and making this the centre of feeding excursions when the tide is down, returning to its home when the water begins to flow, and fixing itself firmly by means of the large fleshy foot projecting from the under side of the body. Numerous limpets are found upon rocks closely studded with acorn-barnacles, and at first sight free from plants which might serve as food. Closer inspection, however, will show in such a case that rocks, barnacles, and even the limpets themselves, are to a large extent closely invested by a covering of minute algæ. It is very interesting to observe these molluscs feeding under such circumstances, a warm still day being usually most favourable for the purpose. By sitting

down and listening attentively a curious rasping sound will be heard, and a little care will show that this is produced by the limpets, some of which will be found to have left their homes, crawling slowly about in the search for food. Selecting one of these, and watching it closely, we shall soon find that the rasping noise is caused by the tooth-studded radula, which is protruded from the mouth and brought to bear with steady strokes upon the crust of algæ, cleaning this off as effectively as could be done by means of a strip of sand-paper. Meanwhile the limpet crawls slowly onwards, moving its snout from side to side, and now and then touching the rock with its mobile pointed feelers. Frequently an individual may be seen to rear itself up against a neighbour's shell, and engage in a bit of friendly house-cleaning. Examination of the neighbourhood of a deeply-sunk scar, which has been occupied for a long time, clearly reveals the large amount of scraping that has been done. As the adjoining supply gets low the limpet wanders farther and farther from home, and is sometimes found as far as 9 feet from its scar. It is clear that such a method of feeding must quickly wear away the rasping ribbon, but this rapidly grows forward, like a finger-nail (see p. 95), as it is used up, the reserve part of it being situated in a long sheath at the back of the thick-walled pharynx within which the mouth-cavity is placed. It is particularly interesting to note that the reserve portion is of extraordinary length in this case, a fact which may perhaps be correlated with unusually rapid wear.

The Limpet's feeding possibilities have not, however, been exhausted in the preceding description. Many individuals live in the neighbourhood of the large brown sea-weeds (species of *Fucus* and *Ozothallia*) known as "wrack", which are common on our coasts. These furnish food to a number of sea-snails, the Limpet being one of them. The present writer was on one occasion fortunate enough to find a limpet actually at work upon the edge of a piece of wrack. This was firmly embraced by the flexible lip, which entirely surrounds the mouth-opening, and held firmly by the strong upper jaw. The radula was then brought to bear from below, and by its rasping action a curved piece of sea-weed was soon scraped away, the injured part suggesting the appearance of a piece of bread-and-butter after some school-boy has taken a bite.

Following down the tide to extreme low-water mark, we get to the Laminaria zone, occupied by broad brown sea-weeds of that genus, which are always partly covered by water. These frequently exhibit the ravages of molluscs, one of the chief depredators being a small smooth relative of the Limpet (*Helcion pellucidum*), the shell of which is beautifully ornamented by radiating blue lines. This little creature lives entirely under water, and eats out a home for itself in the sea-weed, sometimes in the stem-like part, but most frequently in the attached region, which is expanded and fixed to the rock by a number of root-like branches. This limpet either wanders at large over the weed or may feed near its home, scraping out roads for itself in the neighbourhood of its dwelling.

Land-Snails and Slugs (fig. 437).—Among terrestrial forms very interesting observations have been made which prove clearly that the sense of *smell* is used in hunting for favourite sorts of food. Furtado observed the tactics of a common Garden Snail (*Helix aspersa*) in the neighbourhood of a young banana plant which had been placed in a verandah overlooking a small court. He removed the snail, throwing it into the court to a distance of several yards. Next morning the snail was back again in the same place, and was again removed to a similar distance, its further movements being carefully watched. The following morning it was seen on the rail of some steps leading up to the verandah, and in the course of the evening resumed its march, ultimately reaching once more the desired spot. Cooke (in *The Cambridge Natural History*) quotes some interesting observations narrated by Moquin-Tandon in regard to the habits of the Black Slug (*Arion ater*) and the Great Slug (*Limax maximus*), both which are in the main vegetable feeders. His remarks run as follows:—"Anyone can experiment for themselves on the olfactory powers of our common snails or slugs. Moquin-Tandon records two interesting cases, one communicated to him by letter, the other occurring to himself. His correspondent, a M. Parenteau, was one day walking along a dusty high-road, when he noticed near the middle of the road an empty bean-pod, and two Arions eating it. Attributing the meeting of feeders and food to mere chance, he was walking on, when he noticed a second bean-pod, and, about 2 yards away from it, a third Arion hurrying straight towards it. When

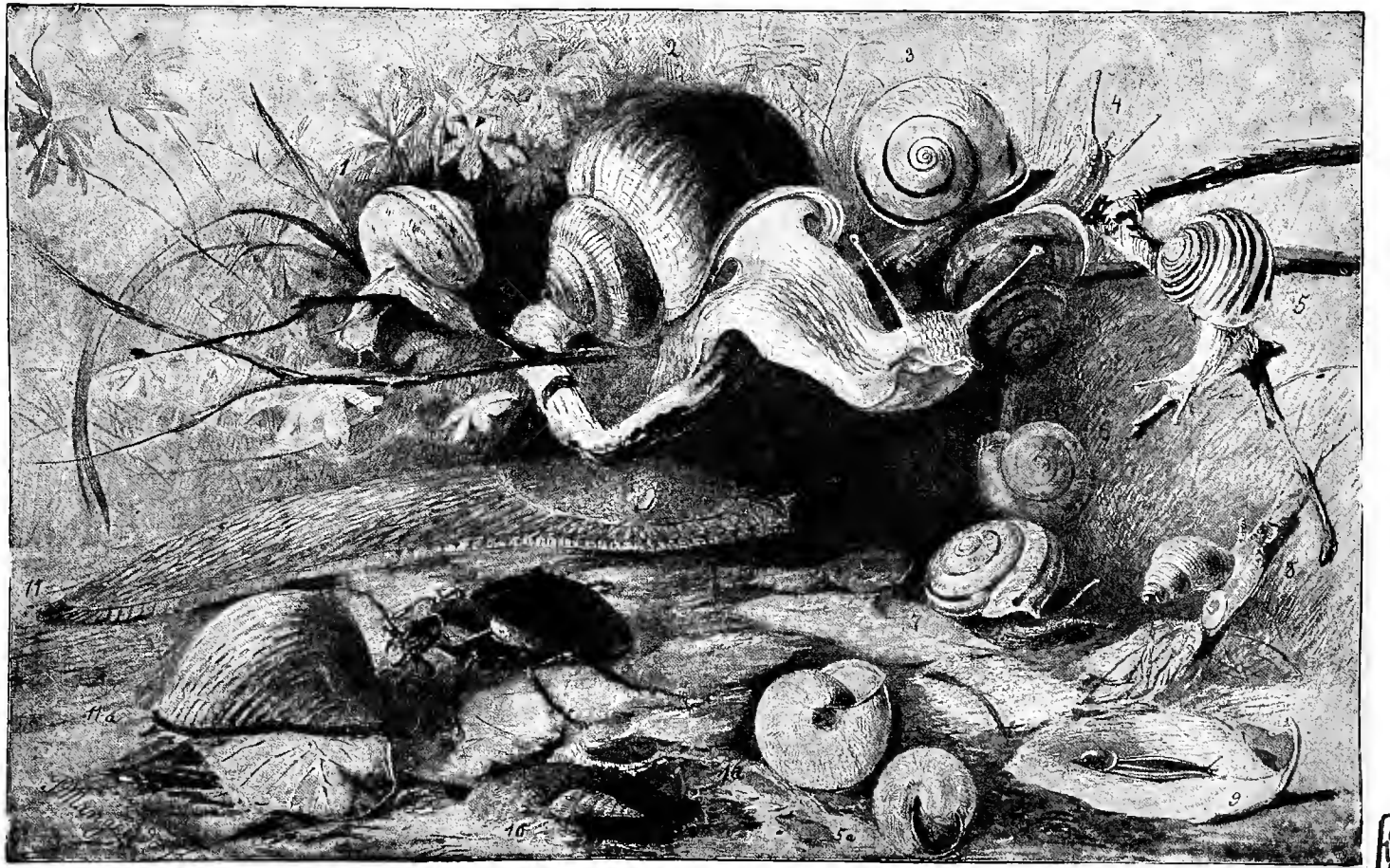


Fig. 437.—Land-Snails and Slugs

1 and 1*a*, Bush Snail (*Helix fruticum*); 2, Roman Snail (*H. pomatia*); 3, Field Snail (*H. nemoralis*); 4, Hedge Snail (*H. arbustorum*); 5 and 5*a*, Garden Snail (*H. hortensis*); 6, Stone Snail (*H. lapicida*); 7, Alpine Snail (*H. ichthyomura*); 8, Round-mouth Snail (*Cyclostoma elegans*), although a land form this belongs to the Prosobranchs; 9, Red Slug (*Dandebardia rufa*); 10, Operculate Land-Snail (*Clausilia plicatula*); 11 and 11*a*, Black Slug (*Arion ater*), extended and retracted.

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the Arion had yet more than a yard to traverse M. Parentean picked up the bean and put it in his pocket. The Arion stopped, raised its head, and turned in every direction, waving its tentacles, but without advancing. M. Parenteau then carried the bean to the other side of the road and put it in a small hole behind a piece of stone. The Arion, after a moment's indecision, started off straight for the bean. Again the position of the precious morsel was changed, and again the Arion made for it, this time without being further tantalized. M. Moquin-Tandon noticed, one rainy day, in the botanical gardens at Toulouse, two *Limax maximus* approaching a rotten apple from different directions. He changed the position of the apple several times, placing it at a sufficient distance to be sure that they could not see it, but they always hit it off correctly, after raising their heads and moving their long tentacles in every direction. It then occurred to him to hold the apple in the air some centimetres above the head of the Limax. They perceived where it was, raised their heads and lengthened their necks, endeavouring to find some solid body on which to climb to their food."

CHAPTER XVIII

THE FOOD OF ANIMALS—PLANT-EATING INSECTS AND MYRIAPODS

The enormous Phylum of ARTHROPODA embraces an extraordinary variety of species, which play the most diverse parts in the economy of nature. It will be convenient, as before, to deal first with the Insects and other air-breathing forms and then with the Crustacea and their allies.

INSECTS (INSECTA)

It has already been explained (see p. 102) that Insects possess three pairs of jaws, which are adapted for biting, piercing, or sucking, as the case may be, and by means of these plant food can be attacked as well as that of animal nature.

The following nine orders are recognized:—

A.—Insects with biting mouth-parts (in the adult).

1. MEMBRANE-WINGED INSECTS (Hymenoptera).—Bees, Wasps, Ants, &c.
2. BEETLES (Coleoptera).
3. NET-WINGED INSECTS (Neuroptera).—Dragon-Flies, May-Flies, &c.
4. STRAIGHT-WINGED INSECTS (Orthoptera).—Cockroaches, Locusts, &c.
5. WINGLESS INSECTS (Aptera).—In some of these the mouth may be imperfectly suctorial.

B. Mouth more or less perfectly suctorial (in the adult).

6. SCALE-WINGED INSECTS (Lepidoptera).—Moths and Butterflies.
7. FLIES (Diptera).
8. FRINGE-WINGED INSECTS (Thysanoptera).—Corn-Thrips, &c.
9. BUGS (Hemiptera).

MEMBRANE-WINGED INSECTS (HYMENOPTERA)

SAW-FLIES.—The first insects to be here considered are Saw-Flies and their allies, distinguished by the absence of the "waist" so characteristic of wasps and the other members of the order.

One of the most striking of these is the Giant Wood-Wasp (*Sirex gigas*) (see vol. i, p. 371), sometimes seen in this country, but much more abundant on the Continent. It is of large size, somewhat wasp-like in appearance as the common name implies, and in the adult condition lives chiefly on honey, like most of its kind. The female is distinguished by the possession of a long, straight boring apparatus (ovipositor) projecting from the abdomen, and often mistaken for a sting. This consists of two sheath-like pieces enclosing the borer proper, made up of an upper gouge-shaped piece and two firm boring rods, the ends of which are beset with saw-like teeth. Besides these parts there is also a strong spine projecting backwards from the tip of the body over the structures just described. By means of this complicated piece of apparatus the Saw-Fly bores a hole through the bark of a felled or sickly fir, and lays a number of eggs in the hole so made. The larvæ which hatch out from the eggs resemble maggots in appearance, and subsist upon the wood, in which they excavate galleries by means of their powerful jaws, and after a variously-estimated time, probably not far short of two years, pass into the quiescent or pupa stage. This develops into the perfect insect, which bores its way out directly to the exterior, near the place where the larva entered into the pupa condition. In some species of Sirex, however, the quiescent stage is assumed when the larva is a considerable distance from the surface of the trunk, so that the insect, when mature, has to gnaw through a considerable thickness of wood, and cases are recorded where pieces of wood containing pupæ have been covered with sheet-lead, and yet even this has not proved hard enough to prevent the prisoners from escaping. An amusing instance of late escape is mentioned in the following quotation from Sharp (in *The Cambridge Natural History*):—

"After becoming full fed, the insect may still pass a prolonged period in the wood before emerging as a perfect insect. As a result of this it not infrequently happens that the insect emerges from wood that has been carried from a distance, and used for buildings or for furniture. A case is recorded in which large numbers of a species of *Sirex* emerged in a house in this country some years after it was built, to the great terror of the inhabitants. The wood in this case was supposed to have been brought from Canada."

Saw-Flies proper include many species well known to culti-

vators from the ravages committed by their larvæ on the leaves of various plants. One of the commonest of these is the Turnip Saw-Fly (*Athalia spinarum*) (see vol. i, p. 371), which often inflicts serious damage upon the leaves of the crop after which it is named. The females of this and other species are provided with a complex ovipositor placed near the hind end of the body, and constructed on somewhat the same lines as the corresponding organ of the Giant Wood-Wasp described above. It consists (fig. 438) of two elegantly-curved saws, each of which can be worked backwards and forwards along a groove in a directing piece, and when not in use is protected by a sheath. The saws have elaborately-toothed edges, and their outer surfaces are ribbed so as to confer a power of rasping. When in use they are protruded from their sheaths and worked alternately, so as to make an incision, within which an egg is then deposited. The larvæ which issue from these eggs somewhat resemble the caterpillars characteristic of moths and butterflies, but differ in certain particulars, as, for example, the presence of more numerous pro-legs than in caterpillars properly so called.

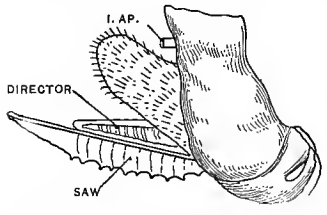


Fig. 438.—Hinder end of a Saw-Fly (greatly enlarged). I. AP. Intestinal aperture.

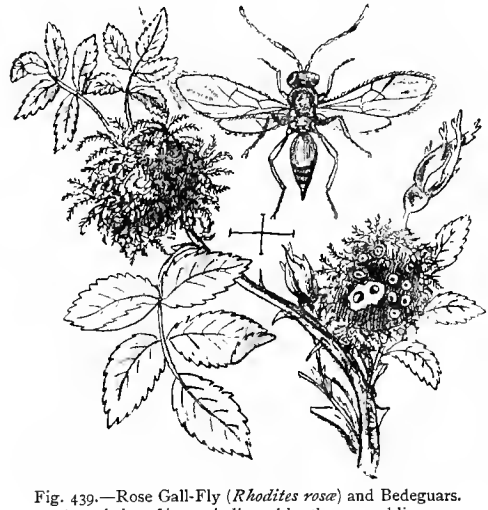


Fig. 439.—Rose Gall-Fly (*Rhodites rosæ*) and Bedeguars. Actual size of insect indicated by the crossed lines.

The remaining species of the Hymenoptera are characterized by the possession of a "waist", and they include many plant-feeding insects, such as most gall-flies, all bees, and certain sorts of wasps and ants.

GALL-FLIES are small or very small insects which are mostly responsible for those curious excrescences upon plants to which the term "gall" is popularly applied. Oaks are especially prolific in these structures, and the tufted red swellings common upon roses, and known as bedeguars, furnish a familiar example of them. The Rose Gall-Fly (*Rhodites rosæ*) (fig.

439) leads to the production of the latter. The minute female insect is provided with a long and slender ovipositor, which is for the most part drawn back into the body when not in use, and which is made up of parts corresponding in origin, though not in shape, to those constituting the similar organs of saw-flies. The bedeguar results from the abnormal growth of a leaf-bud, in which three successive leaves have been perforated in spring by a rose gall-fly. It would appear that the young, actively-dividing vegetable tissue is stimulated to excessive and peculiar growth by the development of the eggs, though the exact nature of the process still requires to be worked out.

Among BEES the most familiar form is, of course, the highly-specialized Honey-Bee (*Apis mellifica*), which, as nearly everyone knows, lives in communities consisting of a queen, workers (undeveloped females), and males or drones. The food of the community is entirely derived from flowers, and consists of the fertilizing yellow dust called pollen, and of the sweet nectar secreted deep within the recesses of flowers, often being contained in specialized tubes ("spurs"), of which typical forms are to be seen in pansy, columbine, and monkshood. The first joints of the hind-feet in the worker are broadened out and provided on their inner surfaces with regular transverse rows of hairs, suggesting in appearance the teeth of a comb. This is for the purpose of carrying pollen to the hive. Specialization of a much more remarkable character, however, is found in the parts of the mouth, fitting them to obtain nectar without destroying their usefulness as biting organs. It has elsewhere been explained (p. 102) that an insect possesses an upper lip (labrum) and three pairs of limbs, modified to serve as jaws, some insects of primitive nature, such as the Cockroach (see vol. i, p. 345), presenting a very unspecialized form of this arrangement. In the worker-bee we find that there is nothing remarkable about the labrum and first pair of jaws (mandibles), the latter being efficient biting structures. The other two pairs of jaws (first and second maxillæ), however, are modified into a long *proboscis* (see vol. i, p. 370), which, when not in use, is folded up on the under side of the body. This consists of an outer sheath formed by the first maxillæ, and a central nectar-conducting piece formed by fusion of the second maxillæ and a slender hairy piece (ligula) which extends far beyond them. This central piece is grooved on its under surface, and ends in a

sort of lappet. Whether the ligula, often called the tongue, is really part of the second maxillæ or a special structure is not definitely known. When in use the proboscis is extended, and then thrust into the nectar-containing organ, the sweet fluid passing up into the mouth partly by capillary attraction and partly by some kind of suctorial action. Within the body the nectar passes into a region of the digestive tract known as the crop or *honey-bag*, from which it is later on returned into one of the waxen cells of the comb, having undergone chemical changes (probably brought about by the saliva), converting it into honey.

Different species of bee differ very much among themselves in the extent to which the proboscis is specialized; in the so-called *short-tongued* bees, for example, this organ is comparatively broad and short, while in some forms it may even be longer than in the honey-bee, as, for instance, in the species of *Euglossa* (a tropical American genus), where it may be of greater length than the insect's body.

Wasps possess *mouth-parts* resembling those of the less-modified Bees. The adults feed for the most part on nectar and fruit-pulp, and the young larvæ are fed in their early stages on similar food, though later on they are commonly provided with animal nourishment.

Ants take place in the very first rank among Insects as regards structure, intelligence, and specialization of habit, their communities in many species being organized in the most wonderful manner. The food largely consists of nectar and other vegetable substances. The mouth-parts include the usual structures, the most interesting peculiarity being found in the large *mandibles*, which possess an unusual power of free movement, and project externally to the other pairs of jaws. The reason for this is to be sought in the varied industrial uses to which they are applied in the economy of the nest.

Certain species of Ant are so fond of nectar that they are termed Honey-Ants, which name is applied to species belonging to very different genera native to Mexico and the United States (*Myrmecocystus*) (fig. 440), South Africa (*Plagiolepis*), and Australia (*Melophorus*). Taking the American forms in illustration it is found that some of the workers gorge themselves to excess on nectar produced by a small oak-leaf gall, so that the abdomen

becomes swelled to a relatively enormous size. This is not, however, a case of individual gluttony, but a device for securing the welfare of the colony, since these living "honey-pots", after making their way back to the nest, feed other members of the community from their abundant store.

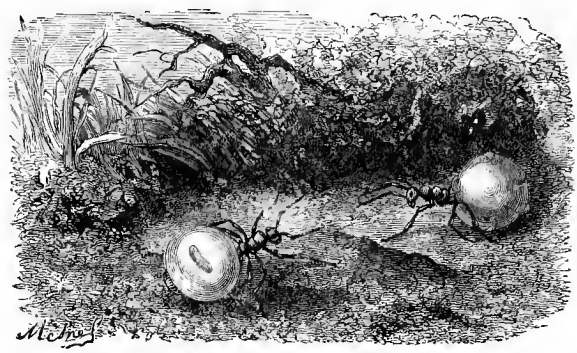


Fig. 440.—Honey-Ant (*Myrmecocystus Mexicanus*)

Ant communities include not only winged males and females, but also one or more kinds of wingless individuals, including *workers* and so-called *soldiers*. This is the case, for example, with the Harvesting Ants of Europe, North Africa, and North America. A familiar passage in the Bible ("Go to the ant, thou sluggard; consider her ways, and be wise: which having no guide, overseer, or ruler, provideth her meat in the summer, *and gathereth her food in the harvest.*"—Prov. vi. 6–8) expresses an old-established belief in the storage of grain by Ants. This was, however, long discredited on the authority of the celebrated entomologist Huber. More recent observations have reconciled the two opposite opinions. For while Huber's observations are correct for northern Ants, there can now be no doubt that storage *does* take place in the case of species about to be mentioned, which inhabit warmer climates and do not pass into a state of lethargy during the winter. Moggridge, for example, has carefully studied the habits of a Harvesting Ant (*Aphænogaster barbarus*) found in Southern Europe, the communities of which include small workers and large-headed soldiers, the former being the members which carry out the harvesting operations. When the end of autumn approaches, these industrious creatures collect from the ground fallen seeds of various weeds (speedwells, nettles, fumitory, &c.), together with oat grains. They are also seen, when dissatisfied with the amount so obtainable, to climb the stems and detach the fruits by twisting them round and round on their stalks, afterwards either carrying down the spoil or dropping it into the midst of the expectant throng

below. Once secured, the harvest is housed in special excavations or "barns", of which a single nest possesses about a hundred, holding between them 20 ounces or more. After storage, germination is prevented from taking place until the food is required for consumption, but the way in which this is done has not yet been discovered. To understand the further operations it must be premised that a seed or grain contains a dormant plantlet, together with a store of nutritive material, mostly starch, for its use in the early stages of growth or germination. At the commencement of this process the starch is converted into a form of sugar, which readily diffuses into the developing plantlet. The sweet taste of sprouting malt is due to this cause. Our Ants allow germination to go on till the sugar is produced, and then nip off the sprouts, which would otherwise absorb it. The nest of an allied North African species (*A. arenarius*) may occupy as large a space as 100 square yards, and extend from 3 to 6 feet into the ground.

Lincecum and M'Cook have studied an even more remarkable North American Harvesting Ant (*Pogonomyrmex barbatus*) which not merely collects grain, but subjects it to a process which leads to the same result as the threshing-machines used by human beings. For after the grains and seeds have been carried into the nest the workers strip off their husks, afterwards bearing these to the exterior to be deposited on refuse heaps.

The Leaf-Cutting Ants (fig. 441) of Tropical America (species of *Atta*, also known as *Œcodoma*) are, if possible, even more

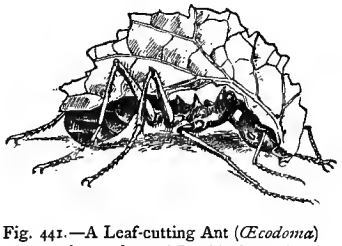


Fig. 441.—A Leaf-cutting Ant (*Œcodoma*) carrying a piece of Leaf (enlarged)

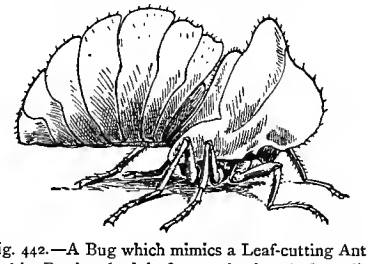


Fig. 442.—A Bug which mimics a Leaf-cutting Ant and its Burden, both in form and colour (enlarged)

interesting than the harvesting forms. Not content with collecting the vegetable food which everywhere abounds in the neighbourhood of their dwellings, they practise a species of plant culture which may well be compared with the mushroom-growing

in which mankind engages. The abodes of these Ants underlie heaps of earth thrown up from below, and in some cases attaining a circumference of 40 yards. From this home as a centre regular paths are made in various directions, so as to make desirable foraging spots readily accessible. These ant-roads may be more or less underground, and extend for considerable distances with a directness rivalling the public ways of the ancient Romans. M'Cook took the measurements of such a road constructed by the North American species *Atta fervens*. The total length was more than 600 feet, of which the first 448 were excavated below the surface at an average depth of 18 inches, while in some parts it was four times as much as this. Worker-ants busily swarm along these roads and ascend the trees or shrubs of which they are the goal, cutting from these small round pieces of leaf. The bits of foliage are carried back to the nest, and there made into a sort of mushroom bed, upon which a kind of fungus (*Rozites gongylophora*) is raised. This, however, is not simply left to itself, but is kept free from undesirable moulds, &c., and its way of growth is modified in some mysterious manner, so as to make it produce little white nodules, which constitute the main food-supply of the Ants.

BEETLES (COLEOPTERA)

A very large number of species belonging to this enormous order, which includes the insects popularly called Beetles, feed upon vegetable matter. The structure of the mouth-parts has already been alluded to (p. 107). Only a few examples can be mentioned here, but further details will be given later on when insect pests are considered. The Common Cockchafer (*Melolontha vulgaris*) has earned an unenviable notoriety on account of its devastations, especially in some parts of the Continent (Holland, Germany, France, &c.), where, during what are known as "chafer years", it appears in millions. Its favourite food consists of the leaves and buds of many fruit- and forest-trees, and its destructive larva, which lives as an underground grub for three or four years, attacks the roots of all sorts of crops. The Cockchafer is one of a group containing some 4000 known species, all apparently of similar habits. The Sacred Scarab (*Scarabæus sacer*) (fig. 443) is a dung-eating member of an allied and larger (5000 species) group. The following inter-

esting account of the habits of this species, as observed by Fabre in Southern France, is given by Sharp (in *The Cambridge Natural History*):—"These insects act the part of scavengers by breaking up and burying the droppings of cattle and other animals. The female Scarabæus detaches a portion of the dung and forms it into a ball, sometimes as large as the fist; this it



Fig. 443.—The Sacred Scarab (*Scarabæus sacer*)

rolls along by means of its hind-legs, by pushing, when necessary, with its broad head, or by walking backwards and dragging the ball with its front legs [notice in fig. 443 the suitability of these parts for such uses]. The strength and patience displayed by the creature in the execution of this task are admirable. Frequently the owner of this small spherical property is joined, so Fabre informs us, by a friend, who is usually of the same sex, and assists her in pushing along the ball till a suitable place is reached. When this is attained, the owner commences to excavate a chamber for the reception of the ball; sometimes the

false friend takes advantage of the opportunity thus offered, and carries off the ball for her own use. Should no disappointment of this sort occur, the scarabæus accomplishes the burying of the ball in its subterranean chamber, and accompanies it for the purpose of devouring it. The feast is continued, without intermission, till the food is entirely exhausted, when the scarabæus seeks a fresh store of provender to be treated in a similar manner". Dung is also collected by this Beetle for the benefit of the larvæ.

The "Wire-Worms" which attack the roots of crops are in reality the larvæ of small insects called Click-Beetles or Skipjacks (*Agriotes lineatus* and *A. obscurus*), so named because they possess a peculiar apparatus which enables them to spring up with a sort of click when they happen to fall on their backs.

Other examples of vegetarian beetles are the little Pea- and Bean-Beetles (*Bruchus pisi*, *B. fabæ*), the Colorado Potato-Beetle (*Chrysomela decemlineata*), and the members of the huge family (some 20,000 species are known) of Weevils. Probably everyone has observed in a batch of ripe hazel-nuts some devoid of kernel, and with the shell perforated by a neat little round hole (fig. 444). This is the work of the grub of the Nut-Weevil (*Balaninus nucum*), which has developed from an egg laid by the parent within the partly-developed nut before the shell is hard, and later on bores its way out in order to seek the ground, where, buried in earth, it passes through the further stages in its life-history.

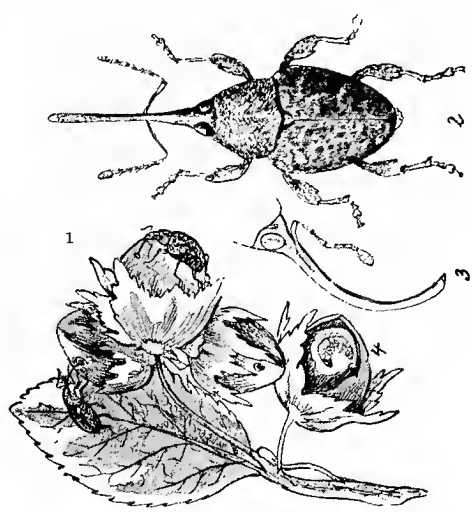


Fig. 444.—Nut-Weevil (*Balaninus nucum*)
1 and 2, Adult weevils (2 being greatly enlarged); 3, snout of weevil (greatly enlarged); 4, nut broken open to show the grub.

NET-WINGED INSECTS (NEUROPTERA)

The insects of this order possess mouth-parts well adapted for biting, and constructed on much the same plan as those of Beetles. Most of the species are carnivorous, and some such have already been described (p. 111). Among those which are

vegetarian, or mainly so, in habit, the most interesting are the various kinds of White Ant, more properly known as Termites (fig. 445), for they differ widely from the true Ants, which belong to the order Hymenoptera. Termites live in complex communities, of which details will be given elsewhere, and one of the two European species (*Calotermes flavicollis*) has been very carefully studied in Sicily by Grassi and Sandias. The communities of this species live within decaying or dead trees, and the primary food is wood in which decay has begun to make its

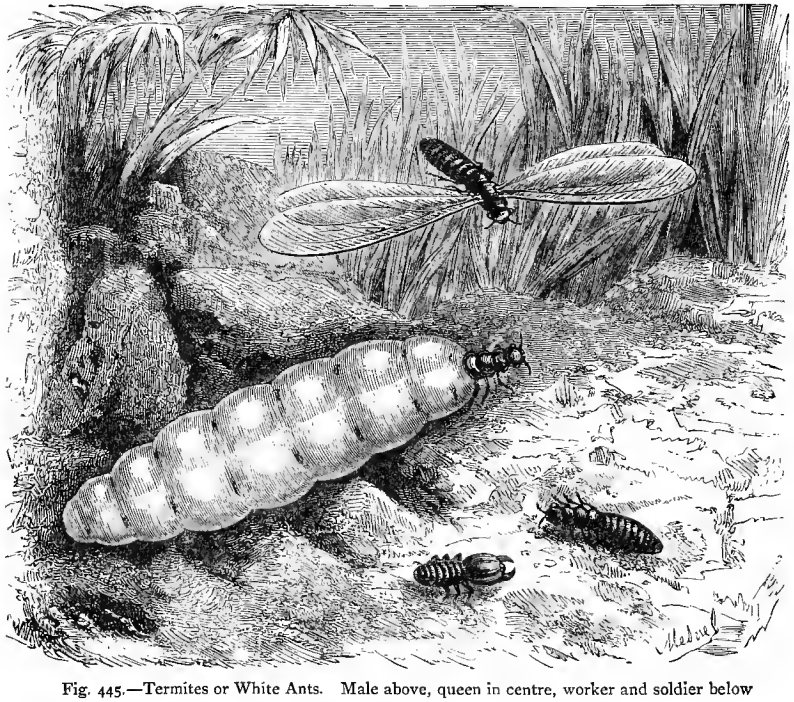


Fig. 445.—Termites or White Ants. Male above, queen in centre, worker and soldier below

appearance. This substance is but very slowly digested, and the voided pellets, from which the nutritious parts have only been partly absorbed, are used once more as food, and so on till finally exhausted. Very young individuals are fed on the saliva of the older ones, and the secretion in question is therefore different in nature from saliva ordinarily so called, which is simply a digestive fluid without nourishing properties. Indeed it may be noted here that such terms as "saliva" and "bile' are very loosely applied when lower animals are described, for there is an unwarrantable tendency, chiefly resulting from our limited know-

ledge, to use the well-understood terms of human physiology in a broad and general sense. These animals, however, are not vegetarians pure and simple, for they eat their own cast skins and the bodies of deceased friends. Cannibalism is also practised, especially by the "soldiers"—specialized blind individuals with large heads and huge mandibles incapable of dealing with the staple food.

A curious Natal species of Termite, described by Haviland, cuts grass and acacia leaves into pieces which are carried into the nest, and it would appear likely that this is for the purpose of fungus cultivation, as in some true Ants (see p. 209), for the same observer has shown that there are both South African and Singapore species which engage in this kind of culture. Such habits of complex insect-communities are curiously reminiscent of the agricultural stage in the history of prehistoric man, which marks the most important step in the evolution of civilized races.

STRAIGHT-WINGED INSECTS (ORTHOPTERA)

The insects of this large and comparatively primitive order possess biting mouth-parts, already (vol. i, p. 345) described in detail in the case of the Common Cockroach. Most of the species are either entirely vegetarian, or at any rate plant food bulks largely in their diet. Among the most notable plant-eating members of the order are the Grasshoppers and Locusts (*Acridiidæ*), distinguished by their comparatively short feelers. A "locust", as defined by Sharp (in *The Cambridge Natural History*), is simply "a species of grasshopper that occasionally increases greatly in numbers, and that moves about in swarms to seek fresh food". A great deal of damage is done by such insects both in Old and New Worlds. To most readers the word "locust" chiefly suggests the creature so called in Exodus, and there described as one of the Egyptian plagues (Exodus, x. 4–6). The Migratory Locust of North Africa and North-west India, *Schistocerca* (*Acridium*) *peregrina*, is most likely the species meant (see vol. i, p. 382).

WINGLESS INSECTS (APTERA)

This order includes small wingless forms which are usually regarded as primitive (see vol. i, p. 384). Their mouth-parts are feeble, and may approach to the suctorial type. Very little

is known as to their habits, but they are supposed to feed on disintegrating vegetable and animal matter. A good example is the shining Silver-Fish (*Lepisma saccharina*) with long antennæ, and three jointed filaments projecting from its tail end. It is found in brown sugar, and among starchy substances. In one section of the order, the Spring-Tails, there is a sort of elastic fork, which can be bent under the body and then liberated so as to enable the creature to leap into the air. One of the most curious of these species is the so-called Glacier-Flea (*Desoria glacialis*), often found on the surface of ice or snow in Alpine regions.

Those plant-feeding insects now fall to be considered in which the mouth-parts are more or less perfectly suctorial.

SCALE-WINGED INSECTS (LEPIDOPTERA)

This order consists of the Butterflies and Moths, which are nearly all plant-feeders. The voracious larvæ, commonly known as "caterpillars", play havoc with all sorts of vegetation, and the most important mouth-parts which they possess are large biting *mandibles*, so that in this respect they differ widely from the adult. The way in which the larvæ feed by biting away pieces of leaf can be observed in almost any kitchen-garden, a notable case being that of the green caterpillars of the Cabbage White (*Pieris brassicæ*), which in some years appear in almost incredible numbers. The larvæ of the Silk Moth (*Bombyx mori*), commonly called "silkworms", furnish another readily accessible instance. Many adult butterflies and moths feed but little or even not at all, but those that do and those that do not feed alike possess an elaborate suctorial *proboscis*, adapted solely for taking in liquid nourishment, generally consisting of the nectar secreted by flowers. This organ consists (fig. 446) of the two much-elongated *first maxillæ*, each of which is in the form of a half-tube,

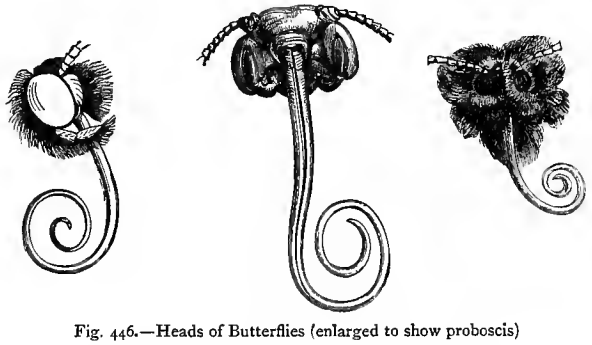


Fig. 446.—Heads of Butterflies (enlarged to show proboscis)

that by means of hook-like hairs can be connected with its fellow so as to form a conducting structure, the length of which is said to reach as much as 10 inches in extreme cases. When not in use the proboscis is kept rolled up on the under side of the head. All the other mouth-parts are in a reduced state, the *mandibles*, for example, being very minute or perhaps even absent altogether, a state of things markedly in contrast to the larval condition.

It is unnecessary for the present purpose to give further details regarding the feeding-habits of Lepidoptera, though it may be noted in passing that the caterpillars of particular species are often dependent upon one or a few sorts of plant. The caterpillars of the Small Tortoiseshell Butterfly (*Vanessa urticæ*) and the Peacock Butterfly (*V. Io*), for example, feed upon the nettle. That a female moth or butterfly should lay her eggs upon the right sort of plant, quite unlike her own food, is one of the most remarkable phenomena in the whole realm of natural history.

FLIES (DIPTERA) (see fig. 90)

It has already been explained that the Two-winged Flies which constitute this order possess a suctorial and, it may be, piercing proboscis, very different in structure from that of a moth or butterfly. The tube is composed of the labrum or *upper-lip*, which is concave on its under side, and the *lower-lip* (labium), which is concave on its upper side and is usually regarded as formed by the fusion of the *second maxillæ*. The *mandibles* and *first maxillæ* are piercing stylets, by means of which female gnats, mosquitoes, midges, and the like penetrate the skin of their victims (p. 121). The males of most of these blood-sucking forms are believed to sustain themselves on plant-juices, and the piercing parts of their proboscis are not so strongly developed as in the female. The larvæ of gnats and mosquitoes are little wriggling worm-like creatures, living in stagnant water, and subsisting chiefly upon decaying vegetable matter.

Strongly contrasting in habit with the preceding forms are the CRANE-FLIES (species of *Tipulæ*), familiarly known as "daddy-long-legs", which, although their mouth-parts are constructed on the same plan as in the blood-suckers, live on the juices of flowers and the like. The larvæ, popularly called "leather-jackets", are

legless grubs which live underground and possess biting mouth-parts, with which, according to some observers, they attack the roots of grasses and other plants.

The wasp-like HOVER-FLIES (species of *Syrphus*) frequent flowers, upon the pollen and nectar of which they feed. Although the piercing mouth-parts are retained they are not known to be of use, though this is one of the innumerable cases where there is a lack of detailed and accurate observation. We have here a good instance of marked difference in feeding habits between larva and adult, for the former is a legless maggot which relentlessly pursues plant-lice (aphides), the juicy bodies of which it sucks as a school-boy does an orange. Closely related to these forms are the Drone-Flies (species of *Eristalis*), which closely resemble bees, and visit flowers for the same reasons as their congeners. The curious aquatic larva is known as the Rat-tailed Maggot (from the long breathing-tube which projects from its posterior end), and feeds upon decaying vegetable matter or upon the refuse matter which saturates the filthy ponds, &c., in which it is often to be found.

Further mention will be made of Diptera which feed on vegetable matter when agricultural pests are dealt with.

FRINGE-WINGED INSECTS (THYSANOPTERA)

The best-known member of this order is the minute Corn-Thrips (*Thrips cerealium*) (see vol. i, p. 355), often found in large numbers in the flowers of grain crops. It possesses four narrow fringed wings, and the most remarkable parts related to its mouth are three piercing stylets, of which two are probably parts of the *first maxillæ*, and the third one derived from the *mandibles*. It is usually stated that they feed upon pollen, and are also able to pierce the flowers in which they live for the purpose of obtaining sap. They are reckoned among the innumerable pests of agriculture.

BUGS (HEMIPTERA)

The Bugs, using the word in a very broad sense, which constitute this large order, possess piercing and sucking mouth-parts, which have already been briefly described (p. 122). The young forms resemble the adults in most particulars of form and structure, including the nature of the mouth-parts, there never being therefore the sharp contrast between a biting larva and a sucking

adult, as exemplified by such insects as moths and two-winged flies. A large number of species feed on the juices of plants, and inject salivary fluid into the punctures they make, often, it would appear, with injurious result. Among the most attractive of these are the comparatively large CICADAS (see vol. i, p. 152), the males of which have earned a sort of doubtful fame from the fact that they are the noisest members of the Insect class. The larvæ are more unlike the adults than is usually the case in the order. Perhaps the most remarkable species, on account of the unique length of time taken by it in passing through its life-history, is the Seventeen-year Cicada (*Cicada septemdecim*) of the United States. Most of the seventeen years is spent underground in the larval stage, during which the food consists of the juices of roots, according to many entomologists.

Another good example of plant-sucking Bugs is afforded by the PLANT-LICE or APHIDES (see vol. i, p. 353), commonly called "green-fly". These minute, delicate insects often propagate at a surprising rate, and damage many kinds of plants. One of the most notorious forms is the Vine-Aphis (*Phylloxera vastatrix*), a North American insect, which, introduced into Europe, has done a vast amount of damage in vineyards. Its life-history is very complex, and includes certain stages which injure vine-roots, and others which produce galls on the leaves of the same plant.

A rather curious family of bugs is that of the FROG-HOPPERS (*Cercopidæ*), including small insects with marked leaping powers. The commonest British species is *Philænus spumarius*, the young of which are surrounded by a mass of frothy fluid, which has been secreted in the intestine. This is the origin of the familiar "cuckoo spits", which are common country objects.

SPIDER-LIKE ANIMALS (ARACHNIDA)

The second air-breathing class of Arthropods, that of the ARACHNIDA (Scorpions, Spiders, MITES, &c.), includes animals of which the large majority are carnivorous. A number of the minute creatures known as MITES are, however, vegetarian in habit. Some of these subsist on dead organic matter, as, for example, the Meal-Mite (*Tyroglyphus farinæ*), and in this case the chelicerae, corresponding to the little nippers of the Scorpion (see p. 125), are, as in that case, pincer-like. The same append-

ages are similarly shaped in the remarkable Gall-Mites, which cause the production of diseased outgrowths on the leaves or buds of various plants. The vine, for instance, may be infested by one of these gall-producing species (*Phytoptus vitis*). The elongated wrinkled body of this creature is almost worm-like, and the two hinder pairs of legs have disappeared, while the others project at the front end of the body. There are also, however, plant-infesting Mites with sharp piercing chelicerae, as in the case of the familiar web-spinning Money-Spider or Red Spider (*Tetranychus telarius*), which is not really a spider at all.

MILLIPEDES (MYRIAPODA)

In the third class, MYRIAPODA, of the air-breathing Arthropods, five orders are included, of which by far the largest and most important are those including the Centipedes (Chilopoda) and the Millipedes (Chilognatha). The former are active carnivorous forms, of which something has already been said (p. 132), while MILLIPEDES (see vol. i, p. 396) are sluggish vegetarian creatures. One of the most abundant British kinds is the Common Millipede (*Julus terrestris*), often found under bark, or else crawling upon hedge-plants. It is a small creature of somewhat worm-like appearance, which coils itself into a spiral form when disturbed or resting. The body is clearly divided into a series of rings that bear feeble, jointed legs, the bases of which are near together instead of wide apart as in a Centipede. The latter arrangement is more favourable to rapid movement than the former, and it is associated with a flattened body and a comparatively small number of limbs. A Millipede, on the other hand, has very numerous *legs*—two per segment except in the case of the first four. Its mouth-parts are adapted for chewing vegetable food (fig. 447), and consist of an *upper-lip*, two powerful biting *mandibles*, and a lobed plate acting as an *under-lip* and formed by the fusion of two appendages. The *feelers* are short as compared with those of a Centipede, to which longer exploring organs are more necessary than in the case of its vegetarian cousin. A Millipede is devoid of the

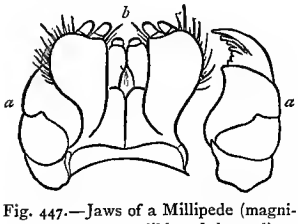


Fig. 447.—Jaws of a Millipede (magnified). *a a*, Mandibles; *b*, lower-lip

poison-claws which play an important part in the capture and slaughter of prey by carnivorous Myriapods.

The Common Millipede and its allies feed largely upon dead vegetable matter which has begun to decay, and they are also reputed to do a certain amount of damage to living plants. Farmers know them by the name of "false wire-worms", "wire-worms" proper being the young of click-beetles (p. 211).

The remarkable genus Peripatus, the only form included in the class PROTOTRACHEATA, the fourth and last subdivision of air-breathing Arthropods, is carnivorous, and has already been described (p. 134).

CHAPTER XIX

THE FOOD OF ANIMALS—PLANT-EATING CRUSTACEA AND LOWER INVERTEBRATES

Having now passed in review examples of vegetarian Arthropods belonging to the air-breathing series, we come to the two classes of CRUSTACEA and XIPHOSURA, which together constitute the aquatic gill-bearing division of the same phylum. The latter class includes only the carnivorous King-Crabs (p. 144), and the former includes a host of forms, most of which are either carnivorous or else act as scavengers. There are, however, interesting exceptions to this.

HIGHER CRUSTACEA (MALACOSTRACA)

Among the Higher Crustacea (Malacostraca) some of the Land-Crabs affect a vegetable diet, as, for example, the Countryman-Crab (*Gecarcinus ruricola*) of Jamaica and other West Indian islands. This has proved a great nuisance to planters, as the shoots and juice of the sugar-cane constitute its favourite food.

A still more interesting animal is the Robber- or Cocoa-nut-Crab (*Birgus latro*) (fig. 448) of the Cocos-Keeling islands, which appears to be a hermit-crab (see p. 137) that has taken to a terrestrial life, and given up the habit of sheltering its tail in a cast-off snail-shell. Hermit-Crabs are believed to be descended from hard-tailed forms, in which the posterior part of the body became soft because it was protected in a new fashion. Should a hermit, therefore, give up its habit of appropriating a snail-shell as a protection, we might expect the tail to become hard once more, and this is actually what has happened to the Robber-Crab. This species is mentioned here because it feeds upon fallen cocoa-nuts, and the following is Darwin's graphic account of the way in which it goes to work in order to extract the fleshy part from the shell and fibrous husk by which it is invested (the extract is taken from *A Naturalist's Voyage*):—"The front pair of legs

[*i.e.* the equivalents of a lobster's great claws] terminate in very strong and powerful pincers, and the last pair but one are fitted with others weaker and much narrower. It would at first be thought quite impossible for a crab to open a strong cocoa-nut covered with the husk, but Mr. Liesk assures me

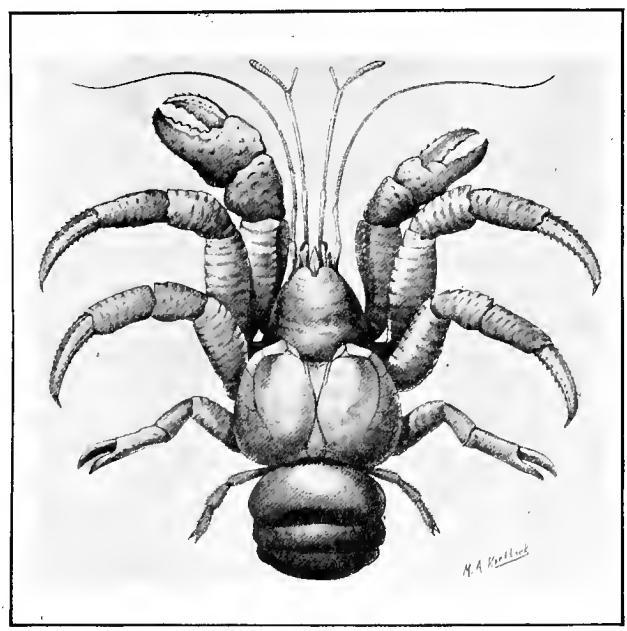


Fig. 448.—Robber- or Cocoa-nut-Crab (*Birgus latro*)

that he has repeatedly seen this effected. The crab begins by tearing the husk, fibre by fibre, and always from that end under which the three eye-holes are situated; when this is completed the crab commences hammering with its heavy claws on one of the eye-holes till an opening is made. Then, turning round its body, by the aid of its posterior and narrow pair of pincers it extracts the white albuminous substance. I think this is as curious a case of instinct as ever I heard of, and likewise of adaptation in structure between two objects apparently so remote from each other in the scheme of nature as a crab and a cocoa-nut-tree." Forbes (in *A Naturalist's Wanderings in the Eastern Archipelago*) gives further details, stating that the proper eye-hole (only one of the three is soft) is pierced by means of the pointed end of one of the walking-legs, the orifice, when sufficiently enlarged, being still further widened by the great claws.

Some of the compressed sandhopper-like forms (Amphipods) and flattened woodlouse-like species (Isopods) also feed on vegetable matter. We have, for example, the destructive wood-boring Crustacean *Chelura terebrans* in the former group, commonly associated with the Gribble (*Limnoria lignorum*), a species of similar habit belonging to the latter order. Other vegetarian Isopods are the little Water Wood-Louse (*Asellus aquaticus*), which feeds chiefly on decaying leaves in ponds, &c., and the Wood-Lice (species of *Oniscus*, *Armadillium*, &c.) (see vol. i, p. 415), land-inhabiting creatures commonly found under stones. In all these cases the *mandibles* are powerful, and well adapted for breaking up the food.

THREAD-WORMS (NEMATELMIA)

The numerous phyla to the members of which the term "worm" has been or may be applied include a very large number of carnivorous forms, many animal parasites, and a crowd of species which affect a mixed diet. Vegetarians pure and simple are the exception. Carnivorous worms have already been sufficiently dealt with (pp. 146–152), and those affecting a mixed diet will be treated along with the forms of other groups which are distinguished by similar feeding habits. In this chapter it will only be necessary to mention certain Thread-Worms (Nematodes) which attack plants, and often do serious damage.

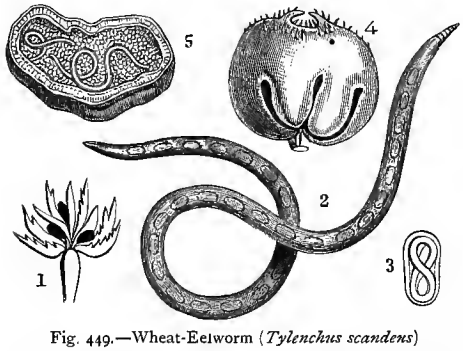


Fig. 449.—Wheat-Eelworm (*Tylenchus scandens*)

1, Diseased spikelet of wheat; 2, eelworm (magnified); 3, young eelworm before hatching (enlarged); 4, diseased grain (enlarged); 5, the same in section, showing worms in interior.

Other related forms live on vegetable substances, but do not attack living plants. A well-known example of the latter is the Vinegar- or Paste-Eel (*Anguillula aceti* or *Leptodera oxophila*). This often abounds in paste or vinegar which has "gone bad", that is to say, in which moulds are growing. It is upon these that the eel is believed to subsist. A near relative of this harmless species is the Wheat-Eelworm (*Tylenchus scandens*) (fig. 449), which infests the wheat plant, and stunts the growth of the seedlings. Nor is this all, for the young worms get into

the wheat-ears and attack the young grains, which become little brown galls, known to farmers as "ear cockles", "peppercorns", or "purples". Other injurious species will be mentioned in the section on economic zoology.

LOWER INVERTEBRATES

The phylum of Hedgehog-skinned animals (ECHINODERMATA) includes voracious creatures like Star-Fish, which feed on animal prey, Sea-Urchins which do this to a considerable extent but at the same time do not despise vegetable food, and forms like Sea-Cucumbers, Sea-Lilies, and Feather-Stars, which are non-predaceous but live on food of both kinds.

The three lowest phyla of the animal kingdom, *i.e.* Sponges (PORIFERA), Zoophytes (CŒLENTERATA), and Animalcules (PROTOZOA) are in the main either carnivorous or else their food is of mixed character.

CHAPTER XX

THE FOOD OF ANIMALS—OMNIVOROUS MAMMALS

Some account having been given of typical animals which feed on either animal or vegetable matter to a preponderating extent, if not entirely, our attention is claimed by those forms which are commonly called *omnivorous*. The term is not very happy, for it implies a more largely varied bill of fare than actually turns out to be the case with regard to many creatures so designated. It is best, therefore, to interpret "omnivorous" as meaning "feeding on both plant and animal substances", the proportion between the two varying greatly in different cases. Even some of the highly-specialized carnivorous forms which have already been described occasionally take a certain amount of vegetable food, while on the other hand some of the confirmed vegetarians may not be above swallowing a certain amount of animal matter. Here, indeed, as elsewhere, it is impossible to establish sharp boundary-lines, and one stage in the life-history of an animal may affect one sort of food while during another stage the nutriment may be quite different. The young of the common House-Sparrow, for example, is fed largely on worms and grubs, while the adult birds are notorious for the damage they do to cultivated crops. And we have seen that in the case of Mosquitoes and their kind there is even a difference between the two sexes in the matter of food, for the female is endowed with troublesome blood-sucking propensities, while the harmless male subsists upon the juices of flowers and the like, though perhaps there may have been a little exaggeration in this matter, at any rate as regards some species.

Space forbids detailed consideration of many omnivorous animals, and it will only be possible to select a few specially interesting examples for description. Beginning as in other cases with the VERTEBRATA, or Backboned animals, we will take in succession Mammals, Birds, Reptiles, Amphibia, Fishes, and the

primitive creatures technically known as Protochordates. First, then, as to Mammals.

MAN AND MONKEYS (PRIMATES)

The majority of the forms belonging to this order (including Man and Monkeys) are omnivorous, though some monkeys are pure vegetarians, and the lowest included species, *i.e.* the Marmozets of South America, feed chiefly on insects and other small creatures. A preliminary account of the structure of the human body has already been given (vol. i, pp. 24–59), but a few points related to the feeding-habits may usefully be reviewed here. The *teeth*, for example, differ on the one hand from the specialized carnivorous condition seen in, say, a cat, and on the other hand from the marked adaptation to a vegetable diet found in a sheep or ox. In a cat we find small pointed incisors, large tusk-like canines, and sharp-edged cutting cheek-teeth. In an ox, on the contrary, there are cutting lower incisors and canines biting against a hard pad above (upper teeth to correspond being absent), and elaborately folded cheek-teeth adapted for grinding. In Man the *incisors* are chisel-like, the *canines* pointed but not aggressively large as in the Cat, and the *cheek-teeth*, with grinding crowns, much less complex than in the sheep. The *salivary glands* of the human species, organs of which the secretion is specially suited for acting chemically on starchy food, are tolerably well developed, but very much smaller relatively than in the purely vegetarian Ox. Taking the other parts of the digestive organs in the three contrasted forms, we find a short gut, simple stomach, and small cæcum in the Cat; long gut, complex stomach, and large cæcum in the Ox. The meaning of these differences is that fleshy food is comparatively easy to digest and absorb, vegetable food relatively difficult, hence the shortness and simplicity in the one form and the length and complexity in the other. The *gut* of Man is of moderate length, the *stomach* simple, and the *cæcum* very small. It may further be added that human beings thrive best on a mixed diet, as has been shown by numerous experiments.

LEMURS (LEMUROIDEA)

The curious LEMURS that have their head-quarters in Madagascar, but which are also represented in continental Africa and

Asia, are for the most part adapted for living on a mixed diet. The species, for example, which belong to the typical Mascarene genus Lemur (see vol. i, p. 79), feed on fruits and other vegetable matters, as well as on nestlings, eggs, lizards, and small invertebrates. The *lower incisor teeth* slope forwards, an arrangement which appears to be of use for removing the firm coverings of certain fruits, while the *canines* are sufficiently large to suggest partly carnivorous habits, and the *cheek-teeth* have crowns which are sufficiently broad to break up vegetable food, and at the same time sufficiently sharp to negotiate animal prey.

FLESH-EATING MAMMALS (CARNIVORA)

The flesh-eating members of the great order CARNIVORA, including the most typical beasts of prey, have already been pretty fully dealt with, but certain familiar omnivorous species belonging to the same order require mention here. The structure of their digestive organs, especially the teeth, diverges considerably from what is found in a cat, tiger, or wolf. Although the stomach is always simple, the digestive tube of those species which affect a mixed diet is, as we might expect, longer than in the purely carnivorous types.

Reference to what has already been said about the typically carnivorous dentition of a Cat (p. 6) will show that all the teeth are specially constructed in relation to the securing and subsequent division of living prey. Attention may particularly be directed to the large, sharp, tusk-like canines, and the knife-edged cheek-teeth. In omnivorous species the front teeth and the anterior cheek-teeth retain the carnivorous character, but the back teeth (molars) belonging to the latter series (molars) possess crowns more or less adapted for crushing vegetable food, as shown by their breadth and the presence of blunt tubercles.

CIVETS.—Some omnivorous forms are included among the Civets (Viverrines), a group including small cat-like forms related to the Cats proper (Felidæ). Of these the best examples are the Palm-Civets (genus *Paradoxurus*) of South and South-east Asia, climbing forms which prey upon birds and their eggs, and also turn their attention to domesticated poultry. A well-known species is the Palm-Cat (*Paradoxurus typus*) (fig. 450), which not only feeds upon birds and eggs, but also plays havoc

with such cultivated fruits as bananas, pine-apples, and coffee-berries.

Bears.—It is, however, among Bears and their allies that most of the omnivorous members of the order are found. It may indeed be stated that the majority of the bear-like carnivores feed on a mixed diet, though to this there are notable exceptions, such as the Polar-Bear (*Ursus arctos*), which is almost purely

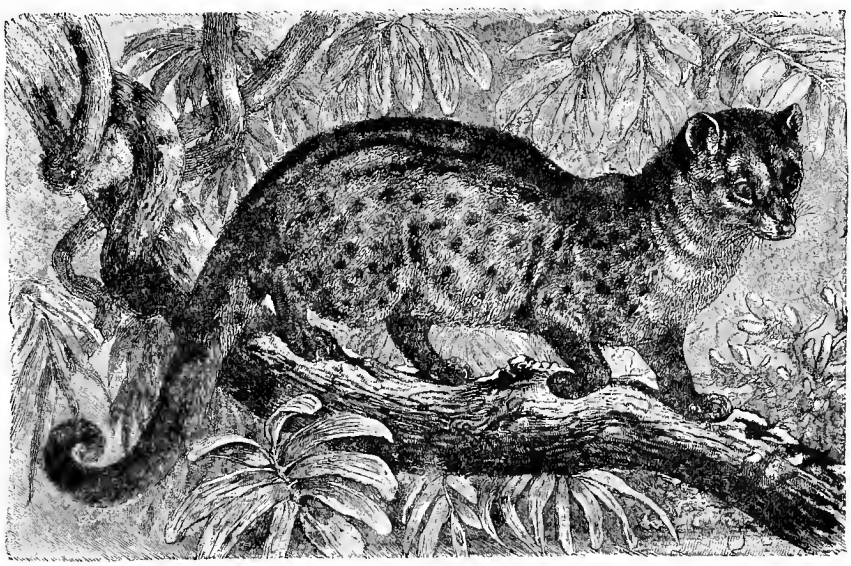


Fig. 450.—Palm-Cat (*Paradoxurus typus*)

carnivorous. There are, on the other hand, strictly vegetarian species, such as the fruit-eating Malayan Bear (*Ursus Malayanus*).

The Brown Bear (*Ursus arctos*) (see vol. i, p. 96) of the Old World is a typically omnivorous species. During the warmer part of the year it lives very largely upon vegetable food, including honey, as well as upon small invertebrates. Its sense of *smell* is well developed, and enables it to scent out edible underground parts of plants, such as tubers and bulbs. On the approach of winter, when this sort of food becomes scarce, the brown bear, at any rate in Europe, takes to flesh-eating, and attacks any wild or domesticated animals which happen to be available. During the most rigorous part of the year, however, like many other inhabitants of cold climates, this species tides over the unfavourable season by *hybernating* in some cave or other sheltered place, passing into a condition of winter sleep, by which the vital

functions are reduced to a low ebb, and subsisting upon its own tissues.

An interesting species is the Sloth-Bear (*Ursus labiatus*) (fig. 451) of Ceylon and India, which feeds mainly upon fruits and honey. It possesses long curved claws of great strength, eminently



Fig. 451.—Sloth-Bear (*Ursus labiatus*)

adapted for tearing open the nests of wild bees, or it may be of termites, which insects also furnish a favourite article of diet. The well-developed sense of *smell* is of the greatest use in detecting concealed food. When the dwellings of termites have been clawed open the bear is reported to vigorously blow away the particles of soil, afterwards sucking out the unfortunate inhabitants of the nest. The narrow, flexible *tongue* and extremely mobile *lips* are well suited for giving effective help in the various feeding operations.

SMALL BEARS.—The so-called Small Bears (*Procyonidæ*) are nearly all American, and include a number of omnivorous forms. A well-known example is the Common Raccoon (*Procyon lotor*) (see vol. i, p. 95), popularly known as the "coon", which feeds both upon the ground and among trees, and though especially fond of all sorts of animal food, from mice and birds down to insects, by no means despises fruit, nuts, and grain. Vogt (in *The Natural History of Mammals*) says of this animal:—"Of all the Carnivora the raccoon is perhaps the cleverest in the use of his fore-paws, for he catches insects in their flight and crushes them between the two front paws, and in general uses

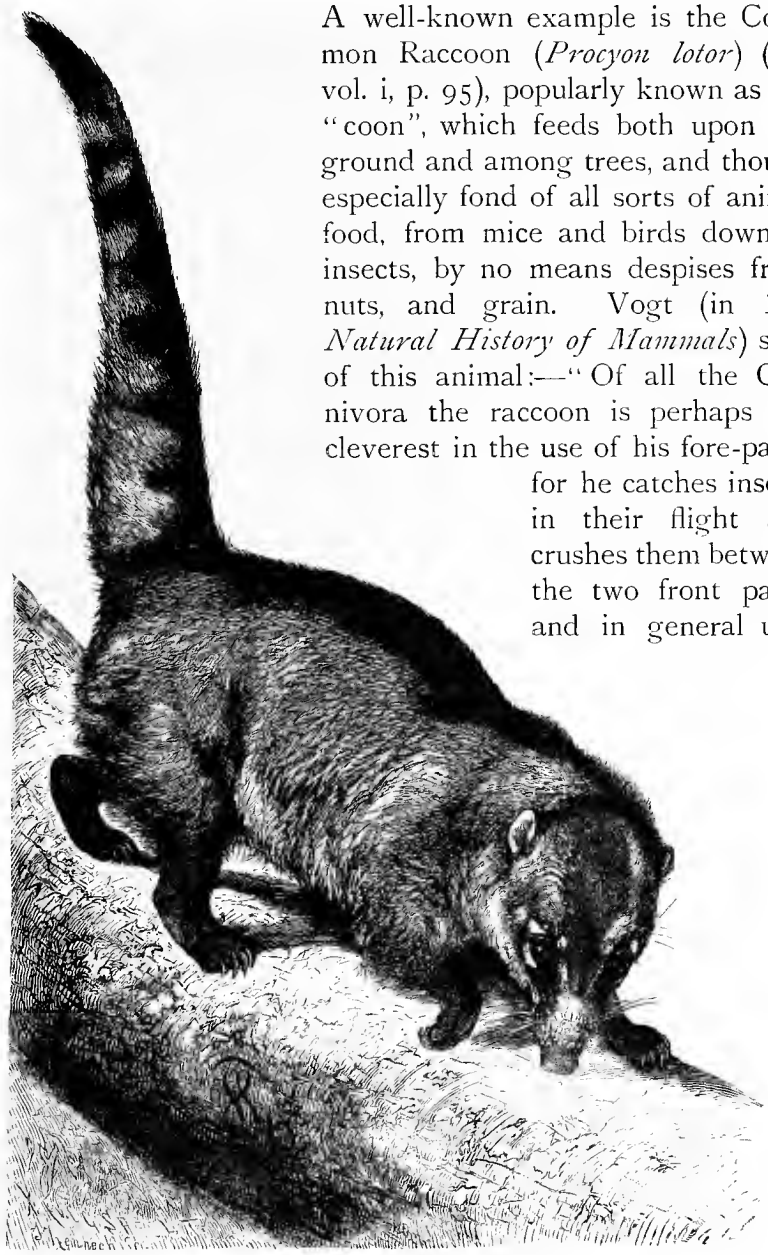


Fig. 452.—Proboscis-Bear or Coati (*Nasua socialis*)

these paws almost like hands in carrying the food to his mouth. If there is water near he never fails to betake himself thither to

dip his food into it and wash it quite clean before beginning his meal." It has often been observed that animals with marked powers of manipulation as regards the organs of prehension by which food is seized and carried to the mouth, are intelligent above the average. Monkeys, raccoons, elephants, and parrots are all illustrations of this.

Similar to the raccoons as regards diet are the related Coatis or Proboscis-Bears (*Nasua*) (fig. 452) of South America, distinguished by long tails, broad at the base, and narrow, inquisitive snouts. The latter organs, to which they owe their name, are used for grubbing in the ground and prying into holes and corners likely to contain available food-supplies.

WEASELS.—Even the family of Weasels (*Mustelidæ*), the last to be considered here of the Carnivora, though including some of the most bloodthirsty and predaceous members of the order, also embraces thorough-going omnivores in the ill-savoured Badgers. Our native species, the Common Badger (*Meles taxus*) (see vol. i, p. 96), unfortunately a creature approaching extinction, except, perhaps, in very wild and remote districts, is a good example. Vogt's admirable summary (in *The Natural History of Mammals*) of his feeding-habits may well be quoted here:—"He takes what nature can offer him. In Siberia he is so entirely carnivorous that he attacks even the herds of cattle in order to slay calves. In Germany he hunts in spring for mice, rats, moles, nests of ants and humble-bees, going about grunting like a pig and turning up the earth with his snout. He thereby makes himself useful in destroying a number of subterranean insect larvæ, caterpillars, worms, and snails. Eggs and small birds which make their nests on the ground are devoured by him just as readily as lizards, serpents, toads, and underground fungi. Truffles and other fungi, as well as a few juicy roots, are eaten as accompaniments to the staple of his meal. To the stings of ants and humble-bees he pays little heed, shaking these assailants off with a grunt. On the approach of autumn the Badger becomes more herbivorous, and grows fatter and fatter every day. Fruits of all kinds, starchy tubers, sweet bunches of grapes and currants, and the like, are then more sought after than mice; but if these, or young hares or partridges, fall in his way, then he eats up with pleasure the dainty with which fortune has provided him." Related species

of similar habits are found in North America. The Ratels, or Honey-Badgers (*Mellivora*), of Africa and India also feed on a mixed diet, and, as one of their names indicates, are especially partial to honey. They attack bees' nests whether these are situated in the ground or in trees.

HOOFED MAMMALS (UNGULATA)

We have just seen that the typically flesh-eating order of Carnivora includes a number of omnivorous animals, and the

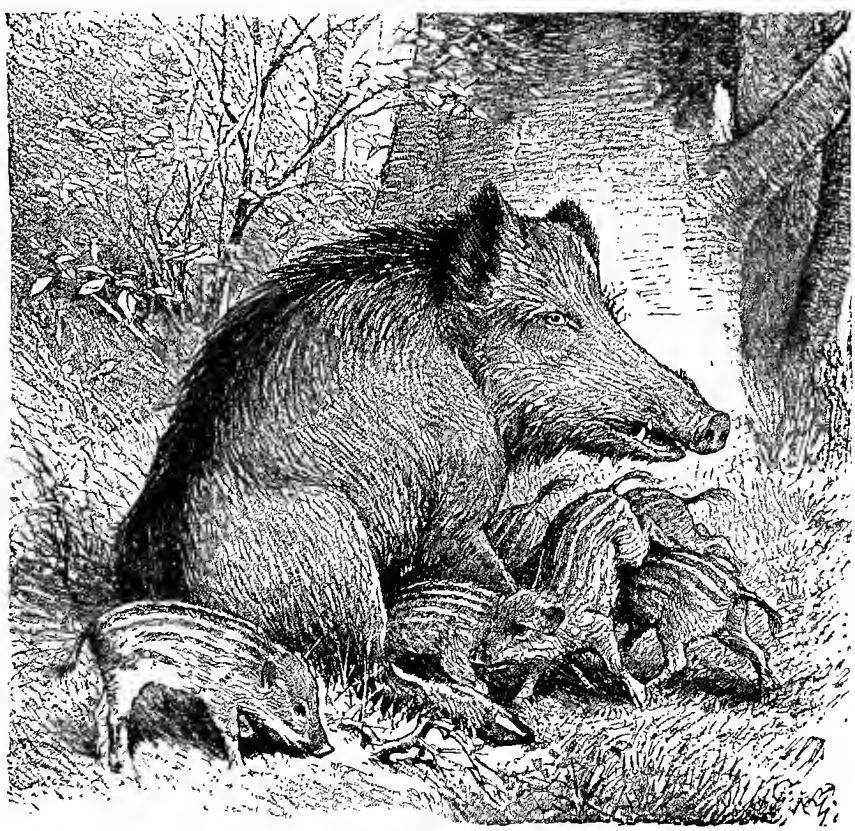


Fig. 453.—Sow and Young of Wild Boar (*Sus scrofa*)

same thing is true as regards the UNGULATA, an order in which most of the members are specialized vegetarians. The species belonging to the Pig Family (*Suidæ*), a division of even-toed Ungulates, are almost proverbial for their omnivorous habits. A good example is the Wild Boar (*Sus scrofa*) (fig. 453), once a

native of Britain, and probably to be regarded as the chief stock from which our domesticated swine have been derived. Pigs are particularly fond of marshy places, and their most characteristic habit is that of "rooting" up the ground in search of various kinds of food. The agent in this process is the strong flexible snout, the flat end of which, pierced by the nostrils, is supported not only by a gristly disc, but also by a special bone. As the position of the nostrils would lead one to suspect, desirable morsels are detected by means of the sense of *smell*, which these animals possess in a highly developed state. Wild Pigs are

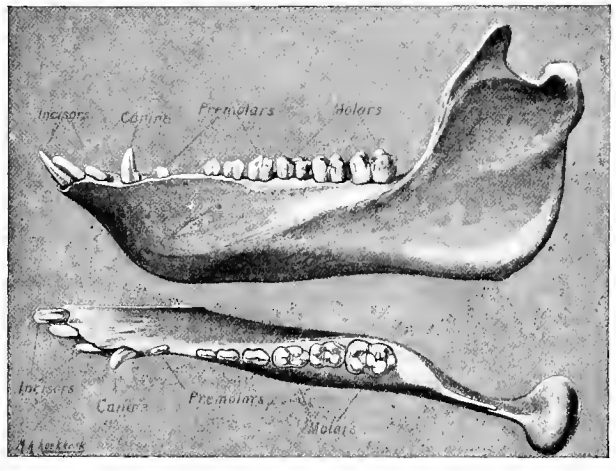


Fig. 454.—Lower Jaw of Pig (*Sus scrofa*), showing teeth

by no means such gross feeders as one might judge, reasoning from the inhabitants of the filthy sties seen in some parts of this country, and, like true epicures, they are extremely fond of truffles in those parts of the Continent where savoury fungi of this sort are fairly common. As most persons know, these dainties grow underground at some distance from the surface, where no indication is to be seen of their presence. Pigs, however, detect them easily by means of their acute powers of smell, and truffle-hunters often employ these animals as guides to the spots where the much-coveted delicacies are to be found. A pig possesses a full complement of teeth (fig. 454), there being forty-four in all, a number regarded as typical for mammals which have not become greatly specialized. There are twelve sharp-edged *incisors*, those of the lower jaw being forwardly-

directed, an arrangement enabling them to easily cut through tubers, &c., which may be met with in the course of the rooting process. Next come the four upwardly-directed *canines*, which work against one another almost like a pair of scissors, and are greatly developed in the male to serve as weapons. The cheek-teeth are twenty-eight in number, and of these sixteen are laterally-compressed *premolars* with cutting crowns, while the remainder are *molars* with large grinding crowns, from which blunt tubercles project. The dentition suggests a mixed diet, for the canines and premolars are modified in the

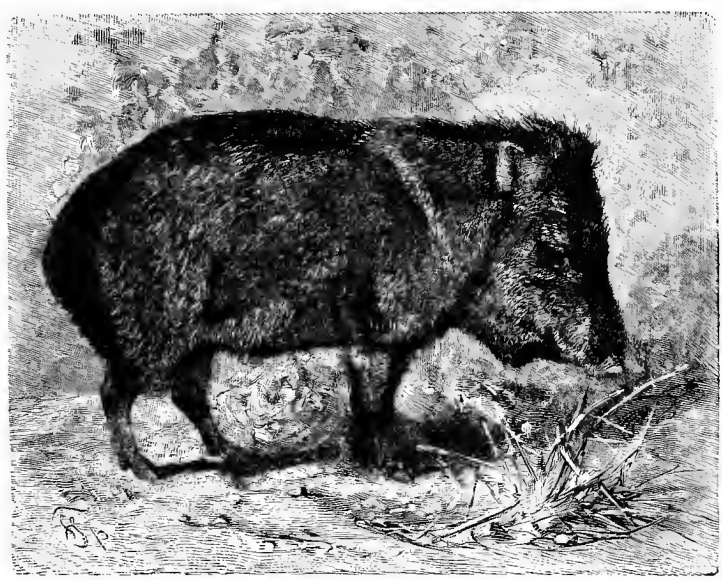


Fig. 455.—Collared Peccary (*Dicotyles torquatus*)

carnivorous direction, the molars, on the other hand, being well-adapted for dealing with vegetable food. The latter tendency is the stronger, and this quite accords with the nature of the aliment, which mainly consists of plants, especially their succulent underground parts, while such fruits as acorns and beech-mast are eagerly sought after. Grubs and other small invertebrates also form part of the food; larger creatures, such as rats and mice, are often devoured, and carrion is not despised. It has already been pointed out that mammals which feed mainly or entirely upon vegetable matter have a much-elongated gut, often associated with a complex stomach and a large cæcum. Pigs exemplify the first of those characters, and also have a moderately-large

cæcum, but the *stomach* is practically simple, though some small pouches are attached to it. On the other hand, the gastric juice has very powerful digesting properties, and this is an adaptation to animal food. The genus Sus, from which our example is taken, is widely distributed through Europe, Asia, and Africa. In America, from Arkansas and Texas south to Patagonia, Swine are represented by the little Peccaries (*Dicotyles*) (fig. 455), which in appearance and habits closely resemble Pigs. They possess only thirty-eight teeth, two upper incisors and four premolars less than in common Pigs, and the upper tusks are downwardly-directed. Though undoubtedly omnivorous, vegetable food constitutes a larger proportion of their food than is the case with Old World Pigs, and an anatomical fact which fully harmonizes with this is found in the possession by them of a complex *stomach*, suggesting the state of things characteristic of Ruminants.

The exigencies of space forbid details regarding omnivorous mammals belonging to other orders, but it may be noted that the large and widely-distributed order of RODENTS includes ordinary Rats and Mice (*Muridæ*), which feed on all sorts of substances, whether animal or vegetable in nature; the Hairy Armadillo (*Dasypus villosus*), among the archaic group of EDENTATES, lives on vegetable food when other nutriment is not available; and the primitive and multifarious order of MARSUPIALS includes certain omnivorous species, such as some Phalangers, Bandicoots, and Opossums.

CHAPTER XXI

THE FOOD OF ANIMALS—OMNIVOROUS BIRDS AND PROTOCHORDATES

Some of the more interesting adaptations which BIRDS exhibit to a purely or mainly animal or vegetable diet have been described in preceding chapters. A large number of species are omnivorous to a greater or less extent, but it would be dull and profitless to do more than mention a few types, as such a procedure could be little more than a list of birds with their appropriate food. It may be noted that in cases where the structure presents no marked peculiarities as regards the digestive arrangements, and especially when the *beak* is a fairly-strong cone of average length, a miscellaneous bill of fare is apt to be found, though no hard-and-fast rule can be drawn. In such Birds, too, it commonly happens that the food varies at different times according to what the season has to offer, and a fact previously mentioned may also be borne in mind, *i.e.* that the food of the nestling may differ from that of the adult. The stock example of this last point is the common House-Sparrow, which, though vegetarian itself to all intents and purposes, feeds its young on worms, caterpillars, and the like.

CROWS (CORVIDÆ)

As might be anticipated, some of the most careful observations regarding the food of birds have been made with reference to species which affect the interests of farmers and other cultivators. Such, for instance, are the Raven, Carrion Crow, Rook (fig. 456), and Jackdaw (species of *Corvus*), well-known members of the Crow Family, now usually placed at the head of the large group of passerine or perching birds, commonly considered to be the highest group of the enormous assemblage of flying-birds (Carinatæ), to which all living forms, except Ostriches, &c., belong. Professor Ritzema Bos (in *Animal Foes and Friends*) thus speaks

of the feeding habits of the species mentioned, using the word "crow" to include them all:—"All crows live both on seeds and animal food, including carrion. Ravens, and sometimes even rooks, attack lambs and sick or weakly sheep, also ducks, geese, fowls, and pigeons. . . . The jackdaw at most steals the eggs of poultry, and the larger crows naturally do the same thing. I myself have often noticed a rook or a hooded-crow sheltered on the branch of a tree near the nest of a tame duck, till this had finished laying an egg. As soon as this was done, and the duck

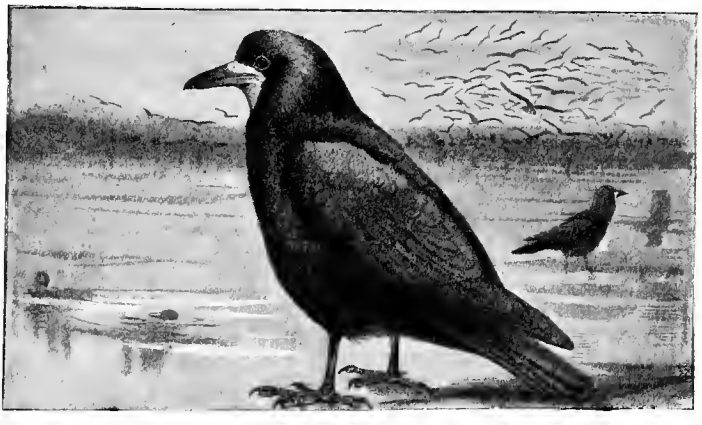


Fig. 456.—Rook (*Corvus frugilegus*)

had left her nest, the crow flew down to feast on the warm egg. All crows, especially ravens, are highly injurious to game; they kill hares and rabbits, . . . young partridges, quails, pheasants, &c. It is also true that all crow-like forms devour voles, though usually only the sick and weakly individuals, which during a 'vole year' are found in large numbers on the fields in late summer. Healthy voles commonly creep too quickly into the ground to be seized by crows. Nevertheless, when these pests are numerous, the crows do their best for agriculture in this respect. Much more harm, however, is effected by them as a result of the large amount of havoc they work among useful insect-eating singing-birds, their attention being more especially directed to the eggs and nestlings. Crows are of great use as destroyers of insects. In cockchafer-years flocks of rooks are to be seen on trees infested by these pests, which they catch very cleverly with the beak, devouring the abdomen and hinder part of the thorax, but letting the remainder . . . fall on the ground. . . . Crows also devour

moths and butterflies, including many harmful sorts, long-legged Crane-Flies (*Tipulidæ*), and other pests possessed of the power of flight. These birds further rid the ground of innumerable noxious insect-larvæ: cockchafer grubs, wire-worms, surface and other caterpillars, mole-cricket larvæ, &c. They also prey on field-slugs and earth-worms. They can often be seen following the plough in order to pick up the grubs and wire-worms which are exposed.

"As to the plant-food of crows, these birds are exceedingly partial to germinating seeds, *e.g.* those of peas and beans, and also the grains of cereals. Germinating maize is particularly appreciated by them. When possible they permit the seeds, &c., to remain in the ground until germination has begun, appearing to know that these have then become sweeter (as the result of the formation of sugar from starch, &c.). Crows also peck the grains, especially when half-ripe, out of the ear . . . liking barley best. Of germinating grains, next to maize, wheat and oats are preferred. They further rob ripening peas, and the nearly mature fruit of the cherry, plum, and apricot. . . . Even potatoes, beet, and mangold-wurzel are not despised by crows. Of the species mentioned the raven is least addicted to seed-eating."

The above gives a good idea of the mixed nature of the diet affected by some omnivorous birds, and it will be noted that there is a considerable difference between related species, the raven, for instance, being fonder of animal food than the other crows, a fact which may be correlated with its formidable beak. Among other omnivorous members of the Crow family may be mentioned magpies, jays, and choughs. The related family of Starlings (see vol. i, p. 155) also includes many omnivorous members, of which the Common Starling (*Sturnus vulgaris*) may be taken as an example.

GEESE, DUCKS, AND SWANS (ANSERES)

Passing over the numerous remaining families of perching birds, many of which include omnivorous forms (*e.g.* birds of paradise, weaver-birds, thrushes, warblers, and larks), mention may be made of GEESE, birds which feed by preference in the neighbourhood of water, either on the sea-shore or inland. Some of the species are practically vegetarian, as, for example, the

Grey Lag (*Anser cinereus*) (see vol. i, p. 177), and many other geese. The Goosander (*Mergus merganser*) and allied forms, on the other hand, are diving birds, which live on fish. Most of the included forms, however, are omnivorous to a greater or less extent. Among geese which are distinguished by this habit may be mentioned the Brent Goose (*Bernicla brenta*) (fig. 457), which during the winter migrates far south from the Arctic regions, and

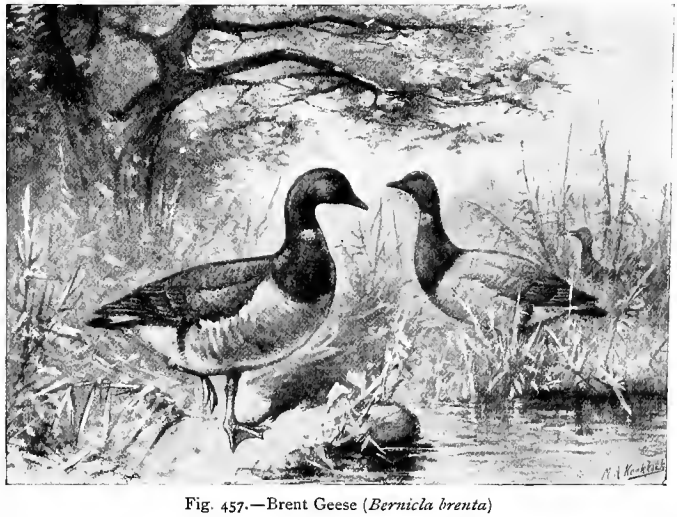


Fig. 457.—Brent Geese (*Bernicla brenta*)

is common on our eastern coasts during the cold part of the year. It feeds on the tenderer sea-weeds and the small animals, such as crustaceans, which live among these. DUCKS and SWANS are omnivorous in habit. The way in which the structure of their bills enables them to secure small aquatic animals has already been mentioned (p. 65). It need only be added here that grass seeds, and the succulent parts of water plants, also form part of their food.

GAME-BIRDS (GALLINÆ)

The group of GAME-BIRDS includes species which for the most part feed on the ground. Their strong, often rather short, beaks and powerful claws are well suited to the mixed food upon which most of them subsist, and which commonly includes the juicy parts of plants, grain, seeds, and small invertebrates such as worms. Many of them use the claws for turning over the earth in search of food, a habit which has earned for them the name of "scratching birds" (Rasores).

The Pheasant Family is one of the most important of those included under the game-birds, and it is exemplified by a number of well-known forms. The smallest species are the Quails, of which one kind, the Common or Migratory Quail (*Coturnix communis*) is an inhabitant of Britain from May to October, and is notable for the wide extent of its range through the countries of the Old World. Its favourite haunts are to be found in fertile plains, and its food consists mainly of seeds, insects, and slugs. The Common Partridge (*Perdix cinerea*) is like a large quail in appearance, and its habits are much the same. Snails are reputed to be a favourite article of diet. This species is found in Britain throughout the year, and has a wide range in Europe and Central Asia. The Pheasant (*Phasianus Colchicus*) of our game-preserves is not a native species, but was in all probability introduced by the Romans. The present breed is of mixed origin, but the home of the original species is to be found in South-east Europe and the adjacent parts of Asia. Thick undergrowth is more congenial to this bird than open country, and it commonly roosts in trees. Its food consists chiefly of berries, grain, worms, &c., and, like most of its congeners, it is a ground-feeder. Some of our domesticated birds are related species introduced from various countries, as the Peacock (*Pavo cristatus*) from India, the Red Jungle-Fowl (*Gallus bankiva*), which is the original Indian stock from which the various breeds of domestic fowls are derived, the Guinea-Fowl (*Numida meleagris*) from West Africa, and the Turkey (*Meleagris gallipavo*) from North America.

Our largest game-bird, the Capercaillie (*Tetrao urogallus*) is a native of the pine-forests typical of the mountainous parts of Europe and Central Asia, and was fairly common in Ireland and Scotland up to about 1770, at which date its extermination was completed. In 1838 it was reintroduced into the latter country. Though partly a ground-feeder upon insects, worms, and berries, its chief food is obtained among the trees in the form of young pine-shoots. The Black Grouse of our moorlands (*Lyrurus tetrix*) is a related form, and so also is the Red Grouse (*Lagopus Scoticus*), which is the only bird peculiar to Britain. The latter species, however, is mainly, if not entirely, vegetarian in habit.

RAILS (GRALLÆ)

A widely-distributed group of forms is constituted by the RAILS, which are closely related to the game-birds. Some are aquatic, but most of them live on the ground, especially in marshy places among thick grasses and sedges, although others prefer dry plains, the last being more particularly the case with certain species which have lost the power of flight. The food is usually

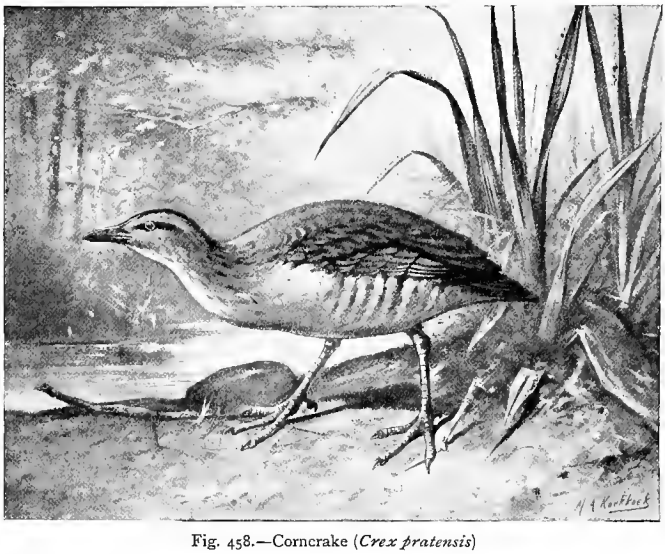


Fig. 458.—Corncrake (*Crex pratensis*)

of mixed character and very varied, and the body is characteristically compressed from side to side, which much facilitates rapid progression through the closely-growing vegetation among which such birds live. Among our seven native species, of which two are rare visitors, the most familiar are the Land-Rail or Corncrake (*Crex pratensis*) (fig. 458) so commonly heard in our cultivated fields, the Moor-Hen (*Gallinula chloropus*), and the Coot (*Fulica atra*), both the last-named being aquatic.

BUSTARDS AND CRANES (ALECTORIDES)

A group related to the Rails is that including the CRANES, TRUMPETERS, and BUSTARDS, most of which are long-necked, long-legged forms, living in the main upon vegetable food, supplemented by all sorts of small animals. Cranes (see vol. i, p.

171) are often confounded with storks, and like them are commonly found in marshy districts. The Common Crane (*Grus communis*) bred in East Anglia up to the end of the sixteenth century, and has at the present time a wide range in Europe and North Asia, migrating during the winter as far south as India



Fig. 459.—Crowned Crane (*Balearica pavonina*)

and North Africa. The Crowned Cranes (fig. 459) of Africa are similar in habits. Trumpeters constitute a small group of South American birds which have been compared in appearance to fowls with long necks and legs, and are found in humid forest regions. Bustards are stoutly-built Old World species, of which the Great Bustard (*Otis tarda*) is of special interest, because it was a native of Britain till about 1838. These birds prefer dry plains and cultivated land. A. H. Evans states (in *The Cambridge Natural History*) that "the diet consists chiefly of juicy plants,

such as young corn and turnips, clover and plantains, but it includes berries and seeds, insects and their larvæ, molluscs, myriapods, frogs, or even small reptiles and mammals."

HORNBILLS

The remarkable HORNBILLS (see vol. i, p. 164), native to the warmer parts of Africa, Asia, and Australia, are reserved as the last example of omnivorous flying birds, because they present a marked exception to the very general rule that a mixed diet is

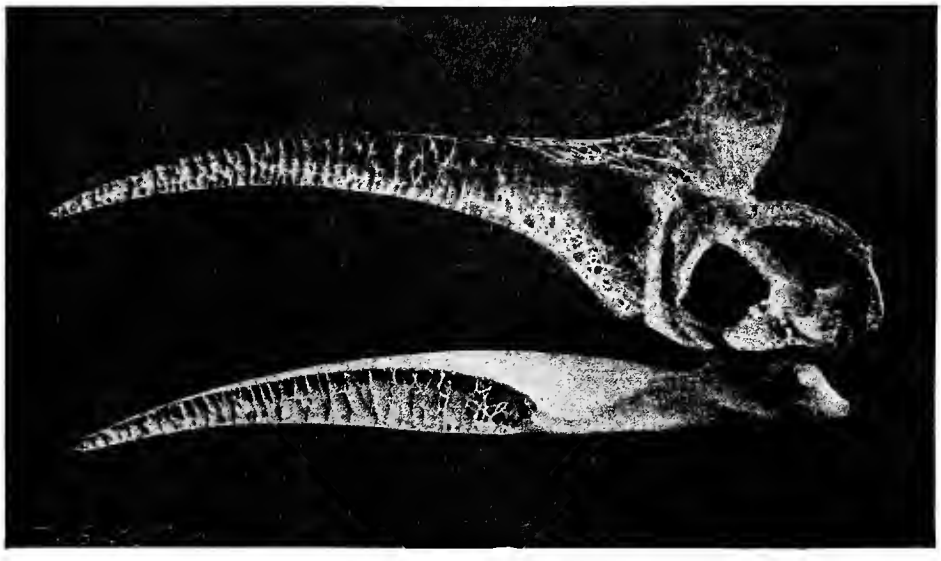


Fig. 460.—Skull of Hornbill (*Buceros galeatus*), in section

associated with what may be called average structural characters. Here, however, we find an enormous beak, suggesting adaptation to a peculiar diet. This organ is not, however, so heavy as it looks, being largely made up of loose spongy bone (fig. 460). The food usually consists of various fruits, roots, insects, and other invertebrates, together with small backboned animals. As a general rule these varied articles of diet are first thrown up in the air, then caught and swallowed whole, the animal part of the food being killed as a preliminary. In explanation of the curious beak it may be remarked that in birds this organ is often used as a defensive weapon, and this appears to be the case in Hornbills, especially in the female, as will be explained elsewhere.

RUNNING BIRDS (RATITÆ)

We next come to the RUNNING BIRDS (Ratitæ) of which the African Ostrich (*Struthio camelus*) is almost proverbial for its omnivorous habits. The general appearance of the bird is familiar to all, and here attention need only be called to the broad short beak and the wide gape. It is essentially a desert form, and is often found associated with herds of antelopes. Its long neck is of obvious advantage in enabling it to have a wide outlook. The food in a wild state consists mainly of herbage, berries, and seeds, but worms, insects, and the like, also small mammals, birds, and reptiles, are by no means despised. The omnivorous habit appears to be much increased in the case of captive specimens. Like all birds in which the food requires crushing, it swallows small stones and grit, as well as, it may be, other hard substances.

The somewhat smaller South American Ostriches (*Rhea*) closely resemble their African cousins in habit. The same is true as regards the Emeus (*Dromæus*) of Australia; but the Cassowaries (*Casuarius*) of the Australian region are mainly vegetarian, and live in forest regions.

PRIMITIVE VERTEBRATES (PROTOCHORDATA)

There being nothing of special interest to detain us in the great classes of REPTILIA, AMPHIBIA, and FISHES, the members of which are predominatingly carnivorous, we come to the PROTOCHORDATES, in which are included the simplest animals that have any claim to be considered vertebrates. They are all omnivorous, and exemplify two ways of feeding that are so typical for many of the lower groups of animals that it will save a good deal of repetition to describe them here in general terms.

SAND AND MUD SWALLOWERS. — Marine sands and muds contain a great deal of nutritive matter partly of vegetable and partly of animal origin. The same is true to a less extent of similar freshwater deposits, and also as regards ordinary earth or soil. Many animals have become swallowers of such substances, the object being to benefit by the nutritious substances therein contained.

CILIARY CURRENTS.—The other mode of omnivorous feeding to be noticed in this place is by means of cilia. These have

elsewhere (vol. i, p. 49) been described as microscopic threads of living matter, which closely beset certain parts in many animals. They may in lower forms cover the external surface, and they also clothe the linings of some internal cavities. They are possessed of the power of spontaneous movement, each individual cilium alternately bending and straightening. As numerous cilia bend in the same direction at the same time, those possessed by aquatic animals often set up definite currents in the surrounding water. Now this water contains a great deal of available food, in the form of minute particles of organic matter of varied origin, together with microscopic animals and plants. As a result the currents in question often play the part of food-bearers, bringing an abundance of mixed diet within reach of the animals which originate them. And many forms of life which are richly provided with these motile threads depend entirely upon ciliary currents for their livelihood.

LANCELETS (CEPHALOCHORDA)

The highest Protochordate is a small somewhat fish-like form, commonly known on account of its shape as the Lancelet (*Amphioxus*) (see vol. i, pp. 293–297). Like all known Protochordates it is exclusively marine, and is found on the coasts of many countries situated in widely-separated parts of the world. It is not unknown, though far from abundant, in British seas. Entirely devoid of jaws, its digestive tube commences in a widely-open funnel-shaped cavity, which communicates behind with a large *pharynx*, the sides of which are perforated with numerous oblique *gill-slits*. These open externally into an *atrial cavity*, that again communicates with the exterior by a small pore placed on the under side of the body pretty far back (see vol. i, p. 294). The interior of both mouth-funnel and pharynx is richly provided with cilia, and these work in such a way that currents of sea-water continually enter the mouth, the particles of food which they bring being conducted back to the stomach and intestine. The water which brings them also serves for breathing purposes, and passing out through the gill-slits ultimately reaches the outside of the body. The food-particles, however, are prevented from doing this, for they are entangled in a sticky substance and conducted back by means of

ciliary action along two grooves, one running along the upper side of the pharynx and the other along the lower. The Lancelet feeds with its body buried vertically in the sand, its front end projecting (fig. 461).

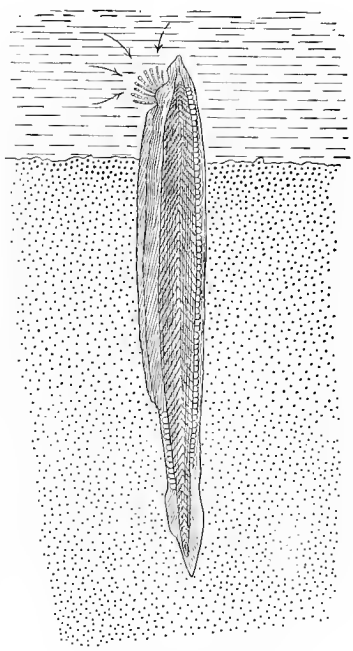


Fig. 461.—Lancelet (*Amphioxus lanceolatus*), feeding

SEA-SQUIRTS (UROCHORDA)

Lower in the scale than the Lancelet are the remarkable and degenerate SEA-SQUIRTS or ASCIDIANS (see vol. i, pp. 297–300). These are either solitary or aggregated into colonies, and may be either fixed to stones, &c., or may float freely in the sea. It will be sufficient to describe briefly the feeding arrangements in a simple fixed form, such as Ascidia (see vol. i, p. 297). We find here a sac-like body, covered by a firm protective coat or test, and fixed by one end. At the other end is the *mouth*, and close to it another aperture from which currents flow out carrying the various products of waste. The mouth leads into a small *mouth-cavity*, and this again into a very large *pharynx*, the walls of which are perforated by a great number of small holes (gill-clefts). The pharynx is suspended in an *atrial cavity*, comparable to that of the Lancelet, and as in that animal opening to the exterior, though in Ascidia the aperture, as already mentioned, is quite close to the mouth. Feeding is effected much as in the Lancelet, *i.e.* currents of sea-water set up by the numerous cilia which beset the lining of the pharynx enter the mouth, bearing with them all sorts of food particles. These are entangled in mucus and carried back to the mouth, while the water passes through the gill-slits, purifying the blood as it does so, and reaches the atrial cavity, thence sweeping out waste products to the exterior. If the animal be touched it shrinks up, ejecting the sea-water contained in the pharynx with some force, and closing the external apertures. This is no doubt a protective measure, and it should also be noted that the beginning of the pharynx is

guarded by a circlet of little sensitive *tentacles*, which perhaps have some selective power, and at any rate to some extent serve to prevent the entry of undesirable substances, such as animals of too great a size, by bringing about contraction of the body-wall, with closure of the apertures as described above. Such protective measures, however, are only partially effective, for parasitic animals are often found in the pharynx.

WORM-LIKE PROTOCHORDATES (HEMICHORDA)

The only other Protochordate to which allusion need be made here is the Acorn-headed Worm (*Balanoglossus*) (see vol. i, p. 301). Like the Lancelet, it is a widely-distributed animal, and is found in shallow water imbedded in sand or mud, by swallowing which it obtains sufficient organic matter to serve as food. The pharynx here presents a very interesting specialization, for it is almost completely divided into upper (dorsal) and lower (ventral) sections. Water for breathing purposes passes into the former and makes its way to the exterior through gill-slits, while food passes back along the lower section to the intestine. The movement in either case is promoted by the action of the cilia with which the digestive tube is lined. The almost complete separation of breathing and food tracts exemplified by the Acorn-headed Worm is an improvement upon the arrangements found in Lancelet and Ascidians, and reminds one of arrangements serving the same end in higher vertebrates, as, *e.g.*, in human beings, where the air used for breathing enters the nostrils and passes back through the passages of the nose to the pharynx, while the food enters the mouth, also to pass back into the pharynx. But in the Acorn-headed Worm both food and breathing water have to enter the mouth, there being nothing comparable to nostrils. More will be said on this subject when dealing in greater detail with breathing and breathing organs.

A short account must now be given of some of the leading omnivorous forms among Invertebrates.

CHAPTER XXII

THE FOOD OF ANIMALS—OMNIVOROUS MOLLUSCS, INSECTS, AND CRUSTACEANS

MOLLUSCS (MOLLUSCA)

Of the five great groups here included, CEPHALOPODA (Cuttle-Fishes, &c.), GASTROPODA (Snails and Slugs), SCAPHOPODA (Tusk-Shells), LAMELLIBRANCHIA (Bivalves), and PROTOMOLLUSCS (Mail-Shells, &c.), the first includes eminently carnivorous forms.

SNAILS AND SLUGS (GASTROPODA)

The majority of the marine members of this group are carnivorous, though many are vegetarians, while the opposite is the case with land forms. The rasping organ which they in common with the Cephalopods possess, and which has been already fully described (p. 95), is capable of dealing with almost any kind of food, and it is not therefore surprising to find that some species are omnivorous. This is especially true for certain Land-Slugs, such as the Grey Field-Slug (*Limax agrestis*) and the Black Slug (*Arion ater*), which prefer vegetable matter, especially fruit, but also devour all sorts of animal substances, and appear to be partial to earth-worms. No interesting specializations, however, to the omnivorous habit have been so far observed, and here, as in almost all other cases, accurate and extended observation on the way of life and its relation to structure are badly needed.

TUSK-SHELLS (SCAPHOPODA)

The curious TUSK-SHELLS (see vol. i, p. 339) which constitute this class are apparently omnivorous. The knobbed filaments they possess, and which can be protruded from the mouth of the shell, are said to be used for the capture of small organisms living in the surrounding sand, especially minute flinty-shelled

plants known as Diatoms, and diminutive animals belonging to the group of Foraminifera, in which the body is usually invested by a calcareous shell. Like Cuttle-Fishes and Snails the Tusk-Shells are provided with a rasping organ, not capable, however, of being protruded so as to act upon large food-bodies. It is probably employed in breaking up the small organisms secured by the capture-filaments.

BIVALVE MOLLUSCS (LAMELLIBRANCHIA)

The BIVALVE MOLLUSCS are all omnivorous, and their food is obtained by the agency of ciliary currents. The Freshwater Mussels (*Anodon* and *Unio*) already described in vol. i, p. 328 will serve as a first example. One of the most striking characteristics is the great reduction of the *head*, which can hardly be said to be present at all. The development of this region is proportional to the intelligence exhibited, and it contains the highest parts of the central nervous system, together with the most important sense organs. Intelligence is closely related to the necessity for finding and seizing food, and there is every reason to believe that the bivalves are descended from forms which engaged in an active search for food, and were possessed of a fairly well developed head. Animals in which food is provided in a mechanical way, without the necessity for individual effort, always tend to become more or less degenerate, and this appears to have been the case with bivalves, in which the head has become more and more reduced, mainly, it would seem, in consequence of the ciliary mode of feeding. The Mussel's body is invested in two shelly plates, situated right and left, and lined by flaps of the body-wall (mantle-flaps), between which is a large *mantle-cavity* into which the body hangs down. The lining of this cavity is clothed with cilia, and there are two large gill-plates on either side, also richly covered with cilia. The *mouth* is a transverse slit situated at the front end of the body, and is entirely unprovided with anything comparable to jaws. On either side of it are two sensitive flaps (labial palps), between which is a food-conducting groove. These palps are also covered with cilia. Observation of a feeding mussel shows that it is obliquely buried in the mud, with the hinder-end projecting and the shell slightly open. Two apertures between the mantle-flaps are visible, a larger one below, into which water-currents con-

tinually stream, and a smaller one above, from which water constantly flows out. The ingoing currents are rich in dissolved oxygen, which is used for breathing, and also bear along innumerable minute plants and animals, which are conducted forwards to the mouth and serve as food, passing on either side along the groove between the two labial palps. The outgoing currents, on the other hand, sweep away all the various products of waste. The flow in both cases is produced and its direction determined by the action of the cilia which line the mantle-lobes and cover both gills and labial palps. The gills, indeed, are as much current-producing organs as anything else, and appear to have been greatly specialized in the Mussel and many other bivalves for the purpose of doing this particular kind of work. As ciliary action is independent of the will, there is not so much scope for intelligence as in, say, a garden snail, and the Mussel is a sluggish creature with dwindled head, living in a happy-go-lucky way by keeping its mouth open and taking in what the Fates provide.

Many bivalve Molluscs are able to feed and breathe when much more deeply buried in mud or sand than is the case with the freshwater Mussel. For it often happens that the two open-

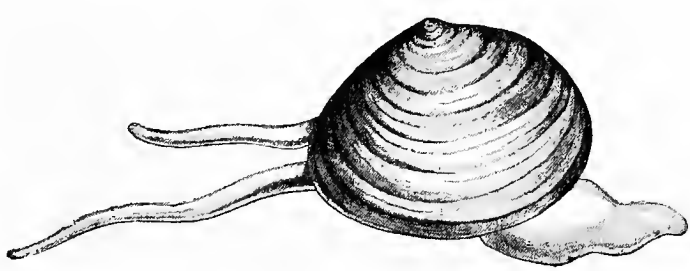


Fig. 462.—Scrobicularia, with siphons and foot protruded

ings serving for the entry and exit of currents are placed at the end of tubes of greater or less length, and the animal gets on quite well if the tips of these just protrude at the surface. A good example of this is found in a little oval form (*Cyclas cornea*) which is abundant in fresh water. If a number of these are placed in a bottle of water and left alone for a short time they will present a very interesting sight, for from the hinder-end of each of them two translucent tubes will be seen projecting upwards. These are the *siphons*, which bear the all-important openings, and close observation enables the two water-currents to be plainly

seen, especially if a little carmine be added to the water. A similar arrangement may be noticed in the estuarine form Scrobicularia (fig. 462).

Not infrequently the siphons are fused together, and the two openings are then seen one above the other, as, for example, in the Sand-Gaper (*Mya arenaria*), which is a common bivalve along part of the British coast.

JOINTED-LIMBED ANIMALS (ARTHROPODA)

The only classes belonging to the phylum of Arthropoda that require any mention in this section are those of INSECTA and CRUSTACEA.

INSECTS (INSECTA)

The great majority of INSECTS, so far as observations have been made, feed either upon animal or vegetable matter, though, as in many other groups of animals, the diet not infrequently includes a small proportion of food other than the favourite kind. Truly omnivorous forms are, however, known, and, as one would naturally expect, these mostly belong to the orders in which the mouth-parts are more or less adapted for biting. A creature of this kind is the Common Cockroach (*Periplaneta orientalis*), a member of the STRAIGHT-WINGED INSECTS (ORTHOPTERA), the structure of which has elsewhere been described (vol. i, pp. 343–350). At least one authority (Brunner) considers that the natural food of this and other allied forms in a wild state consists of dead animal matter; but be that as it may, the Cockroach is undoubtedly omnivorous, though this may partly be a result of its semi-domestication as an "unbidden guest".

Another common straight-winged Insect, the Earwig (*Forficula auricularia*), which is often unjustly charged with entering and damaging the human ear, also affects a mixed diet. It undoubtedly devours insect larvæ, small snails, &c., but also eats fruit and parts of flowers, though some authorities consider this is only done when the supply of animal food fails.

Certain social WASPS and BEES are examples of omnivorous NET-WINGED INSECTS (HYMENOPTERA). Among these are the Common Wasp (*Vespa vulgaris*) and the Hornet (*V. crabro*). The food consists of insects, nectar from flowers, honey stolen from bees, and the flesh of various sweet fruits. The following

interesting particulars are given by Sharp (in *The Cambridge Natural History*) of the way in which the queen wasp feeds the young larvæ of the colony she has founded:—"As the eggs soon hatch, and produce larvæ that grow rapidly, the labours of the queen-wasp are chiefly directed to feeding the young. At first she supplies them with saccharine matter, which she procures from flowers or fruits, but soon gives them a stronger diet of insect-meat. This is procured by chasing living insects, and the hornet is said to be very fond of the honey-bee, but, as a rule, Diptera [*i.e.* two-winged flies] are the prey selected. When an insect has been secured, the hard and innutritious parts are bitten off, and the succulent parts, more especially the thorax, which contains chiefly muscular tissue, are reduced to a pulp by means of the mandibles; this is offered to the larvæ, which are said to stretch out their heads to the mother to receive the food, after the manner of nestling birds."

Examples of carnivorous and vegetarian ANTS have already been given (pp. 103, 206), and it need only be added here that many of the social kinds, including several British species, feed on both animal and vegetable matter. As to the former, it is interesting to note that ants, especially in tropical countries, play the part of scavengers, and share with vultures the office of devouring dead bodies. This propensity is sometimes utilized in this country when a carefully-prepared skeleton of some small animal is desired, for if the carcass be placed in the neighbourhood of an ants' nest it will soon be picked perfectly clean. On the other hand, ordinary ants have a great love for sweet substances of all sorts, and cases are frequent where they raid houses, and particularly confectioners' shops, in search of such things as sugar, honey, jam, or articles into the composition of which these enter.

The TWO-WINGED FLIES or DIPTERA possess much-specialized suctorial mouth-parts (see pp. 120, 121), commonly used for obtaining either animal or vegetable food. Allusion has already been made to the case of Gnats (pp. 120, 215) and the like, where the female sucks blood, while the male is believed to live on plant-juices, which may be put paradoxically in some such statement as "the individual is limited to one kind of food, but the species is omnivorous". The common House-Fly (*Musca domestica*) (fig. 463), however, is truly omnivorous, and settles

with annoying impartiality and persistence upon almost all of the many sorts of food which constitute the diet of the mixed feeder, Man. The mouth-parts of this insect are purely suctorial in nature, and lack the piercing stylets which the females of so

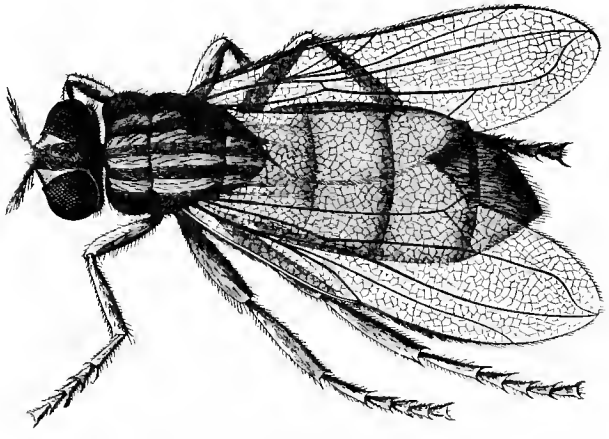


Fig. 463.—House-Fly (*Musca domestica*), enlarged

many not very distantly related species use with such unpleasant efficiency.

The members of the large order LEPIDOPTERA, which includes MOTHS and BUTTERFLIES, are almost exclusively vegetarian in habit. The specialized suctorial mouth (see pp. 214, 215) of the adult is adapted for feeding on plant-juices, while the caterpillar is provided with stout mandibles, which are most efficient biting organs. Yet Carpenter points out (in *Insects: Their Structure and Life*) that "Butterflies sometimes forsake honey for such unsavoury food as blood from the wound of a mammal or the juices of a putrefying carcass. Several instances are known of caterpillars which eat other insects. The larva of *Cosmia trapezina* [the Dun-bar Moth] feeds on oak and other leaves, but devours caterpillars smaller than itself which happen to get in its way; while other species are said to prefer insects to leaves whenever the opportunity arises. A small 'looper' caterpillar has been observed to eat a larva three times as big as itself." In speaking of the Dun-bar Caterpillar, Stainton (in *British Moths and Butterflies*) says:—"It feeds in May and June on oak, birch, &c., and should be carefully avoided by the collector, as it is extremely apt to devour other larvæ that happen to be domiciled with it".

CRUSTACEANS (CRUSTACEA)

Among scavenging forms like those included in the HIGHER CRUSTACEA (Malacostraca), though animal food, including carrion, is the favourite diet, omnivorous species might well be expected to exist, and this is actually the case. A good example is the Common Crayfish (*Astacus fluviatilis*) (fig. 464) of our rivers, which resembles a small lobster in appearance and in the most essential features of its structure. It feeds upon small frogs, fishes, and the like that venture within its reach, and does not disdain offal, which is indeed the most effective bait employed in its capture. Invertebrates such as worms and other small creatures are also appreciated, and the diet also includes a considerable variety of plants and roots. During the warmer parts of the year crayfishes commonly leave the water in the evening, and search for food along the river banks. They live in any natural crannies which happen to be available, and also burrow extensively in the river banks, often doing a considerable amount of mischief in this way. During the winter season they adopt a more passive mode of feeding than at other times, lurking at the mouth of their dwellings in wait for such toothsome morsels as may pass within their reach, and which are secured by their powerful nippers. The long sensitive feelers are able to explore a considerable area round the mouth of the burrow, and constitute, so to speak, an intelligence department giving prompt notice of the presence of edible objects.

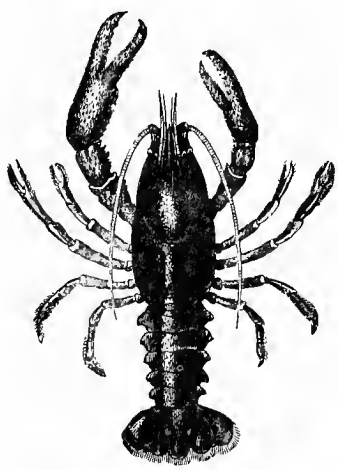


Fig. 464.—Common Crayfish (*Astacus fluviatilis*), reduced

A curious omnivorous form is found in a freshwater Prawn (*Atya*), which inhabits the West Indies, and is about the size of an ordinary marine prawn. The limbs corresponding to the nippers of a crayfish are comparatively small, but end in slender pincers, and the first pair of legs closely resemble them. The food consists of the organic matter abundantly present in the mud where the prawn lives, and the pincers are used for scraping

this up and moulding it into small rounded portions forming convenient mouthfuls.

Many apparently omnivorous forms are found among the LOWER CRUSTACEA (Entomostraca), of which the BARNACLES present a very interesting arrangement by which food is secured. Here are included the stalked Ship-Barnacle (*Lepas*) (fig. 465), and the stalkless Acorn-Barnacle (*Balanus*). Innumerable individuals of the latter roughen the rocks on many parts of the British coasts. In either case the plan of structure is the same (see vol. i, pp. 417–419), and a rough idea is conveyed by Huxley's simile of a man lying on his back with head fixed to some firm object, and getting a living by kicking food into his mouth. But the barnacle is better off than a man in respect to limbs, possessing, as it does, six pairs of long slender appendages, which have been compared to tendrils, and are beset with numerous bristles. If one of these animals is placed in a vessel of sea-water the feeding process may be easily observed, and furnishes a curious and interesting sight. First of all the shell opens, and then the slender "legs" are rapidly thrust out, and as rapidly withdrawn with a scooping action, acting, as it were, like a sweep-net, which brings innumerable minute organisms and nutritive particles within reach of the mouth.



Fig. 465.—Ship Barnacles (*Lepas anatifera*)

Both salt and fresh water are tenanted by innumerable hosts of minute free-swimming creatures, among which the lowly Crustacea known as COPEPODS swarm in myriads. A fresh-water type, Cyclops, has elsewhere been described in detail (see vol. i, p. 420). The shape of the body has been likened to half a split pear, the curved side being dorsal and the flat side ventral. From the broad head-end project two pairs of well-developed *feelers* which row the animal along, and at the same time are no doubt the chief agents by which the presence of food is detected. The *mouth* is placed a little way back on the under surface, and is provided with four pairs of *jaw-like limbs* capable of dealing with minute animals and plants, to say

nothing of small particles of organic matter which may be present in the surrounding water. Behind them come at least four pairs of *forked limbs*, which, by their regular forward-and-backward swing, assist in locomotion, and also sweep edible matters within reach of the jaws. Dr. Vosseler (in Zacharias' *The Animal- and Plant-Life of Fresh Water*) makes the following interesting remarks as to the feeding habits of the free-swimming members of this group of Crustacea:—"The food of all free-living Copepods consists of small particles of animal and vegetable matter which are found on the surface of the bottom-mud, on the stems of plants, &c. Protozoa and microscopic algæ appear to afford the chief supply. As these are always present together, it is difficult to make out whether these animals are actually omnivorous, or whether one or other kind of food is taken up accidentally. According to some observations, the mother devours her own children, and this cannibal behaviour suggests that the Copepods may be purely carnivorous. It is very amusing to watch these animals searching for food. If the vessel in which they have been placed contains plants, they browse among the debris covering the surface of these, picking their way in a methodical manner. When the stomach is sufficiently filled, the animal seeks once more the society of its comrades."

Another widely-distributed group of the Lower Crustacea is that of the OSTRACODS (see vol. i, p. 419), which includes a large number of species of small marine and freshwater forms, living on the surface of the mud, &c., at the bottom, or swimming among water-plants. They are enclosed in a bivalve *shell*, almost like that of a freshwater mussel, and possess, like Copepods, two powerful pairs of *feelers*, serving not merely as sense organs, but also as means for effecting swimming or assisting progression on a firm surface. There are but three pairs of *jaws*, and behind these are situated two pairs of pointed *legs*, used both in locomotion and for scraping food forward to the mouth. This food appears to be partly of vegetable, partly of animal nature.

The last group of Crustacea to be mentioned is that of the PHYLLOPODS, distinguished by their flattened leaf-like limbs, and including a comparatively small number of species, which are mostly inhabitants of fresh water, or of salt lakes and lagoons. There are two sub-groups, one embracing fairly large forms, of which Apus has already been described as a type (vol. i, p. 421).

It not infrequently makes its appearance in spring in small temporary accumulations of fresh water, and is native to many parts of the world. The greater part of the well-segmented body is covered above by a large overlapping oval *shield*, while the under side bears the *mouth*, provided with three pairs of *jaws*, and a large number of leaf-like *feet*. The animal swims on its back, being, as it were, paddled along by the perpetual swinging of the feet backwards and forwards. There is a longitudinal groove between the rows of limbs, along which food is conducted to the mouth, and even when swimming no doubt a certain amount of food is passed along this, in the current of water set up by the feet. Apus is also able to browse on the surface of the mud or of water-plants, much in the same way as has been described above for Cyclops.

The second sub-group of the Phyllopods is that of the Water-Fleas (*Cladocera*), much smaller creatures than their immediate relatives, and including some marine forms, though most live in fresh water. A common type is Daphnia (see vol. i, p. 419), a short-bodied creature, of which all but the head is enclosed in a bivalve *shell*. Swimming in a jerky sort of way is effected by means of the relatively enormous second pair of *feelers*. There are but two pairs of *jaws*, and behind this a small number of flattened *limbs*, which by their constant movement maintain a flow of water along the under side of the animal, which serves both for breathing purposes, and also brings with it minute organisms and particles which serve as food.

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